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ABSTRACT

A study was conducted in the Navy to evaluate the effectiveness and efficiency of individualized instruction (II) compared to conventional instruction (CI). Comparisons were made concerning the relationships of method of instruction, ability level, and type of training task to training time, training costs, end-of-course grades, and fleet supervisor ratings for graduates of 19 Navy "A" Schools including more than 5000 persons. Major findings and conclusions of the study were the following: (1) II and CI were found to be equally effective in preparing sailors for operational fleet jobs; (2) within the II category, self-paced and computer-managed instruction were found to be equally effective training methods; (3) II benefited higher ability students more than it did lower ability students; (4) no evidence was obtained concerning which method of instruction most benefited lower ability personnel; (5) CI did not benefit one ability level of students over another; and (6) whether CI or II was more effective in teaching training tasks depended on course content. It was inferred from the study that training time, and thus cost, could be reduced by converting current CI courses to an II format--at least for higher mental ability students. (Other reports will be forthcoming from these studies.) (KC)

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Technical Report 117

A COMPARISON OF INDIVIDUALIZED AND CONVENTIONAL INSTRUCTION IN NAVY TECHNICAL TRAINING

Eugene R. Hall
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Training Analysis and Evaluation Group

March 1982

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FOREWORD

The Training Analysis and Evaluation Group (TAEG) was tasked by the Chief of Naval Education and Training (CNET) to conduct a study to determine the relative effectiveness and efficiency of individualized instruction for different kinds of training tasks and ability levels of trainees. A series of reports is being prepared to document different, specific aspects of the TAEG program. This is the first report in that series. It deals with overall, interschool analyses of training effectiveness and efficiency measures. Subsequent reports in the series will present:

- results of intraschool analyses of training effectiveness and efficiency measures
- a critical review of literature relevant to issues involved in assessing instructional method effects on students
- results of analytical efforts concerning officer courses and an enlisted course that uses both individualized and conventional instruction.

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report is the first in a series of reports that will document the results of a study conducted to evaluate the effectiveness and efficiency of individualized instruction (II) compared to conventional instruction (CI). The present report provides information concerning the relationships of method of instruction, ability level, and type of training task to training time, training costs, end-of-course grades, and fleet supervisor ratings for graduates of 19 Navy "A" Schools.

(continued on reverse)

20. ABSTRACT (continued)

Data were obtained on over 5,000 Navy technical school graduates of II and CI courses.

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SUMMARY OF THE STUDY

The Chief of Naval Education and Training (CNET) tasked the Training Analysis and Evaluation Group (TAEG) to assess the effectiveness and efficiency of individualized instruction (II) relative to conventional instruction (CI). To the extent that differences in training effectiveness and/or efficiency were found to exist, the further purpose of the study was to determine if these differences are related to student ability levels and/or to specific types of training tasks.

Two measures each of training effectiveness and training efficiency were examined. Student end-of-course grades were used as an internal criterion of training effectiveness. Fleet supervisor ratings of the adequacy of training for identified school graduates were used as an external criterion of effectiveness. Training efficiency measures were reflected by student time to complete training and by an individual training cost measure derived from total instructional costs for a given course. Student ability levels were represented by Armed Forces Qualification Test (AFQT) percentiles obtained by converting their Armed Services Vocational Aptitude Battery (ASVAB) test scores. The instructional content of the various courses examined during the study was equated to a common base by classifying learning objectives of each course into one of five generic task categories: fact, procedure, category, rule, principle.

Nineteen Navy "A" schools were examined. Ten of the courses were conducted using II formats (eight were self-paced courses, two featured computer managed instruction). The other nine courses were conducted under conventional, group-paced instruction.

A correlational approach was used to conduct the study. Record data were collected on over 5,000 graduates of the 19 enlisted technical schools. The results of all statistical analyses performed on the data are presented succinctly in section IV of the report. Major findings and conclusions of the study are summarized below.

1. Individualized instruction (self-paced and computer managed) and conventional group-paced instruction were found to be equally effective ways of preparing sailors for operational fleet jobs. This conclusion is based on comparisons of fleet supervisor ratings on 1,229 graduates of CI with ratings on 1,186 graduates of individualized courses.

2. Within the II category, self-paced and computer managed instruction were found to be equally effective training methods as reflected by fleet supervisor ratings.

3. Individualized instruction, as it was conducted during the time period examined, benefited higher ability students during training more than it did lower ability students. Relative to the lower ability students, higher ability personnel mastered more course content (i.e., had higher end-of-course grades) and completed training in less time.

4. No definitive evidence was obtained concerning which method of instruction most benefits lower ability personnel.

5. Conventional instruction did not benefit one ability level of students over another during training. End-of-course grades for conventionally trained students were equivalent across all ability levels.

6. Fleet supervisor ratings were not dependent on school performance. No significant relationships were found between supervisor ratings and graduate end-of-course grades or time-to-complete training.

7. Fleet supervisor ratings did not depend on ability level or sex of the graduate.

8. When course content is classified into generic training tasks, II was found to be more effective than CI in courses that taught primarily procedure tasks. Conventional instruction was more effective than II in courses that taught primarily rule or principle tasks.

9. No one method of instruction was found to be universally more effective in training all of the different types of tasks to different ability level students. The evidence of this study suggests that a combination of methods used within a given course for conveying different instructional contents would likely be more effective than use of a single method for an entire course.

10. Definitive conclusions concerning the efficiency of II relative to CI could not be reached from the data of this study.

The available data showed that overall training costs were higher for the II courses studied than for the CI courses. However, it cannot be concluded that II is more costly than CI since different courses with different contents and lengths were taught under each method. Similarly, time to complete training was found to be less overall for graduates of II courses than for those of CI courses. Again, however, because of differences in the courses studied, it could not be concluded from this study that individualizing instruction necessarily reduces time required for training.

Evidence was obtained, however, that bears on the time reduction issue. Mental Category 1 and 2 personnel required significantly less time to complete training under II than Mental Category 3 and 4 personnel (under II). From this, it can be inferred that converting current CI courses to an II format would likely reduce the time required for training for at least the higher mental category groups (although the average course completion time cannot be specified). This inference is consonant with the findings of previous research which assert generally that student time is reduced when courses are converted from a CI to an II format--although the previous research did not relate the reductions to particular ability groups.

General recommendations are made within the report concerning the use of II in Navy technical training. In addition, areas are identified where additional information is required to develop a more complete understanding of factors involved in assessing and improving the efficiency and effectiveness of II. In this regard, two additional work efforts have been initiated by the TAEG. The first is concerned with identifying definitive baseline estimates of average student time to complete training under II. The second effort is concerned with improving the conduct of individualized instruction within the NAVEDTRACOM.

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SECTION I

INTRODUCTION

BACKGROUND

A recent review of the status of individualized instruction (II) within the Naval Education and Training Command (Zajkowski, Heidt, Corey, Mew, and Micheli, 1979) identified a number of areas in which additional, detailed information was required to optimize the use of II in Naval technical training. One recommendation concerned the need for an effort "to determine the relative effectiveness and efficiency of individualized instruction for different kinds of training tasks and ability levels of trainees." Knowledge of the existence of and specific nature of any such differential relationships would materially assist decision makers in selecting instructional strategies for different training situations. Subsequently the TAEG was tasked by CNET[1] to conduct the study recommended.

PURPOSE OF THIS STUDY

The purpose of the present study was to assess the effectiveness and efficiency of II relative to conventional instruction (CI). To the extent that differences in training effectiveness and/or efficiency were found to exist, a further purpose was to determine if these differences were differentially related to student ability levels and/or to different types of training tasks.

STUDY REPORTS

A number of reports dealing with different, specific aspects of the TAEG program are planned for publication. These are identified below.

The present report focuses on interschool comparisons to address the overall objectives of the study. This report provides information, obtained from studying 19 different Navy "A" schools, about training effectiveness and efficiency relative to the major variables of the study; i.e., method of instruction, student ability level, and type training task.

Another technical report will provide detailed information about each school/course involved in the study program. The major focus of this second report is on intraschool analyses of the relationships between student ability levels and measures of training effectiveness and efficiency.

A selective review of research and technical literature bearing on issues related to differential training effectiveness will be presented in a third report. The report will summarize and discuss the major findings of the literature and describe previous approaches used to assess differential effectiveness.

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[1] CNET ltr Code N-53 of 22 Apr 1980.

Two of the courses studied during the work program were taught using self-paced (SP) instruction at one location and group-paced (GP) instruction at another. One of these courses, Hull Maintenance Technician (HT "A"), is also dual-phased. The other, Damage Control Assistant (DCA), is an officer course. These special courses required statistical treatments different from those used in other analyses. Consequently, the results concerning instructional method effects on training effectiveness/efficiency obtained with these courses will be reported separately from the other investigations.

Another planned report will deal with the procedures used to equate the content of the different technical courses to a common base; i.e., into generic task classifications. It will also present information concerning differences in classifications made by school subject matter experts (SME) and research personnel. The results of comparisons between different training task classification systems will also be presented.

Finally, an executive summary of the entire study program will be prepared. It will summarize the major findings of the study and provide overall study conclusions and recommendations.

ORGANIZATION OF THIS REPORT

The remainder of this report is presented in five sections and seven appendices. Section II presents the technical approach of the study. Section III contains the results concerning the evidence for differential effectiveness and efficiency as related to the major variables examined: method of instruction, type training task, and student ability level. A discussion of the results and the interpretations that can be made are given in section IV. Conclusions and recommendations are presented in section V. Section VI describes additional work that has been initiated by the TAEG in the II area.

Appendix A provides a concise summary of previous research findings concerning II versus CI used in military settings. Information concerning the Armed Services Vocational Aptitude Battery (ASVAB) is contained in appendix B. ASVAB scores were used as measures of student ability for the present study. Appendix C presents the training package given to SMEs for classifying instructional content into generic task categories. Elements of the cost data base used in assessing training efficiency are discussed in appendix D. Appendix E identifies the schools studied during the work program. Appendix F presents a description of the hierarchical regression model used for data analysis. Information obtained from analysis of missing data in the study is provided in appendix G.

SECTION II

TECHNICAL APPROACH

This section presents the technical approach to the study. A perspective on the study is presented first. This is followed by a brief description of previous research concerning the effectiveness and efficiency of II versus CI. Subsequently, discussions of the variables examined, the samples of courses and graduates involved in the present study, and the analytical design of the study are provided.

STUDY PERSPECTIVE

The study was designed to answer two major questions:

1. Are significant, relative differences in training effectiveness and/or efficiency associated with individualized instruction versus conventional instruction?

2. If there are differences, are they related to different kinds of training tasks and/or ability levels of trainees?

Since experimental methods were impractical to employ within the context of an ongoing military training system, a correlational approach was used to conduct the study. Under this approach, statistical analyses are performed on record data to determine if significant relationships exist among variables of interest.

Within the approach selected, the procedural steps consisted of:

- acquiring background information and knowledge
- selecting relevant variables including identifying sources of data on the variables
- selecting courses taught under each of the basic instructional methods
- selecting samples of graduates of the courses
- collecting appropriate data
- analyzing the data.

Each of these topics is discussed further below.

BACKGROUND

At the beginning of the program, a brief literature review was conducted to obtain background information for the study. The review focused on a number of topics and issues relevant to the present investigation including:

- findings of, and methodologies employed in, previous studies conducted in both academic and military environments concerning the effects on training effectiveness/efficiency of different instructional methods

- various definitions and meanings of the concept of ability and student achievements related to differing ability levels

- types of, and previous uses of, learning task classification systems
- student learning of different types of instructional content.

Information obtained from the literature review was used in designing aspects of the present study, in developing study lines of inquiry, and in selecting the analytical strategy used. In addition to these uses, the body of knowledge available in the literature was found to be of considerable general interest. Consequently, a separate technical report is being prepared to integrate and consolidate the information contained in the various sources.

Of immediate and direct interest to the present TAEG program, however, were those studies which compared the use of II versus CI in military settings. Orlansky and String (1979) reviewed these efforts. Their review indicated that:

- II is as effective as CI in terms of student end-of-course achievement scores
- the efficiency of II is significantly better than that of CI in terms of student time to complete instruction
- training costs for II are lower due largely to student time savings
- the addition of computer support to self-paced instruction does not significantly increase student time savings.

Additional findings of the Orlansky and String review are presented in appendix A of this report.

Orlansky and String noted that the previous studies contrasting II and CI were more or less controlled experimental studies, were of short duration, and used small numbers of subjects. The authors cited the need for information about the effects of II used over a longer period of time within an operational training context where situational factors differ considerably from those involved in the previous research. The CNET tasking of TAEG required an assessment of II effects within Naval Education and Training Command (NAVEDTRACOM) schools where both methods are used routinely for diverse skill and knowledge training. Thus, the present TAEG study complements previous research by assessing the generalizability of prior findings.

STUDY VARIABLES

Seven major variables, three predictor and four criterion variables,[2] were selected for study. The variables, the measures of the variables employed, and the sources of data on the variables are identified in table 1. Further discussions of these variables and data sources are provided below.

---

[2] Precise definitions of these terms may be found in various statistical sources; for example, Finn (1974) and Cohen & Cohen (1975).

PREDICTOR VARIABLES. The major predictor variables were method of instruction, trainee ability level, and type training task.

Method of Instruction. The primary predictor variable of the study was instructional method. Two basic methods were of interest: individualized instruction and conventional instruction. Individualized instruction involved self-paced (frequently referred to as IMI for instructor-managed instruction) and computer-managed courses (CMI). Conventional instruction involved group-paced (GP) classroom instruction.

Ability Level. Ability levels of trainees constituted the second major predictor variable. For the present study, ability levels of trainees were represented by student scores on the ASVAB. This test is routinely administered to all armed services enlistees.

The ASVAB consists of 12 subtests. The composition of the battery prior to October 1980 is shown in appendix B. Various combinations, or composites, of ASVAB subtest scores are used by the Navy to determine an individual's eligibility for attendance at specific technical schools. Scores from three of the battery subtests can also be used to derive an Armed Forces Qualification Test (AFQT) percentile score (see appendix B). These percentile scores provide a measure of general ability. They can also be used to group individuals into mental categories. AFQT percentile scores (derived from the pre-October 1980 conversion routines) were used to represent ability levels of graduates for making comparisons across courses. A subsequent TAEG report will present relationships between composite scores and the other variables of interest.

Types of Training Tasks. The third predictor variable was the types of tasks trained in school. Definitive conclusions concerning the value of II versus CI for training different types of tasks require that the same tasks be taught under each method. Unfortunately, the same courses (and, consequently, the same tasks) are not taught under each of the two basic methods of instruction, and it was beyond the scope of the study to create this condition experimentally. Thus, the matching of tasks under different methods of instruction was approximated by using a generic task classification system. The content of the different courses (i.e., tasks taught) was equated to a common base so that appropriate comparisons could be made. The use of these comparisons assumes that the psychological processes involved in the acquisition of generic tasks are similar regardless of the specific context in which the learning occurs.

For the present TAEG study, a modification of the Instructional Quality Inventory (IQI) method (Ellis, Wulfeck, & Fredericks, 1979) was used to equate skill and knowledge items taught in each of the courses studied to a common base. Subject matter experts at each school classified statements of the school's learning objectives into one of five types of information content: fact, category, procedure, rule, and principle. The classifications are described in table 2. (See appendix C for a description of the training

TABLE 1. MAJOR PREDICTOR AND CRITERION VARIABLES

Variable	Measures	Source
PREDICTOR		
Ability Level	AFQT, Composites	CNET 015
Method of Instruction	SP, CMI, GP	CNET, CNTECHTRA
Type of Training Task	Five Generic Tasks	IQI (SMEs)
CRITERION		
EFFECTIVENESS		
End-of-Course Grades	Final Grades	School Records(SP + GP), CNTECHTRA (CMI)
Training Adequacy Ratings	1-5 Scale	TAS (CNET)
EFFICIENCY		
Cost of Course	Average Cost to Produce One Graduate (Per Session)	CNET Accounting System
Time to Complete	Contact Hours	CNTECHTRA (CMI), School Records, SMEs, NITRAS (SP + GP)

TABLE 2. INSTRUCTIONAL QUALITY INVENTORY CONTENT TYPES

Content Type is:

Fact:	If the student must recall or recognize names, parts, locations, functions, dates, places, etc. Example: name the parts of the ---.
Category:	If the student must remember characteristics of similar objects, events, or ideas, OR if the student must sort or classify objects, events, or ideas according to characteristics. Example: identify target types from sonar signal displays.
Procedure:	If the student must remember a sequence of steps which apply to a single situation, OR if the student must apply the steps to a single piece of equipment or a single situation. Example: Field strip an M-16 rifle.
Rule:	If the student must remember a sequence of steps and decisions which apply in a variety of situations, OR if the student must apply the sequence across a variety of situations or types of equipment. Example: Use mathematical formulas such as Ohm's law.
Principle:	If the student must remember how or why things work the way they do, or cause-effect relationships, OR if the student must use his knowledge to explain how things work or predict effects from causes. Example: Based on knowledge of electronic theory, predict effect on the _______________ circuit if ----.

Source: Ellis, Wulfeck, & Fredericks (1979) package given to the SMEs for classifying course learning objectives using the IQI system.)

In addition to those made by school SMEs, classifications of the same school-trained skill and knowledge items were also made (at TAEG request) by Navy Personnel Research and Development Center (NPRDC) staff. The NPRDC staff who made the classifications routinely use the IQI system and were involved in its development. Also, the questionnaire items were classified using a second task classification system, TECEP (see Braby, Henry, Parrish, & Swope, 1978), to assess differences between classification schemes. Comparative analyses of differences between raters using the same classification system and differences between classification systems are currently being performed. The results of these analyses will be provided in a later TAEG report.

Miscellaneous Predictor Variables. In addition to the three primary predictor variables discussed above, the effects of two other variables, sex of the graduate and geographic location of the school(s), were also assessed.

CRITERION VARIABLES. Two measures each of training effectiveness and training efficiency were used as criterion variables. The effectiveness measures were end-of-course grades and fleet supervisor ratings of school training adequacy. The efficiency measures were time-to-complete training and training costs.

Training Effectiveness Measures. End-of-course grades which reflected how well graduates performed in school were used as an internal measure of training effectiveness. Fleet supervisor ratings which reflected graduate job performance were used as an external measure of course effectiveness. Internal measures of student learning achievement were available at the schools. External measures of student learning achievement were available at CNET.

The external measures consisted of fleet supervisor ratings of the adequacy of school training for particular tasks which graduates are expected to perform on the job. External criteria of training effectiveness were of special interest to the study. The Orlansky and String (1979) review of II versus CI contrasts in military settings noted that previous studies were confined to comparisons on measures of student learning achievement available at the schools (see appendix A). External criteria of training effectiveness were apparently not used (or were unavailable) for assessing the effects of different instructional methods.

Fleet supervisors' ratings of training adequacy on identified courses and graduates were available at CNET in the NAVEDTRACOM Training Appraisal System (TAS) data base. The CNET Special Assistant for Training Appraisal (CNET 015) routinely collects feedback data, via mailout questionnaires, from first-level fleet supervisors of recent technical school graduates. Random samples of graduates are drawn from the total pool of course graduates during a given time frame.

Table 3 shows the type of data collected on school graduates that was of interest to the study. Fleet supervisors rate on a 5-point scale the adequacy of school training for an identified course graduate. Training adequacy judgments are made for a number of specific tasks for which a given technical school provided training. The task statements listed on a feedback questionnaire are currently prepared by technical training staff for a given course. The statements are based on the learning objectives of that course and thus reflect specific skills and knowledges taught at a school.

TABLE 3. EXAMPLES OF TRAINING APPRAISAL SYSTEM DATA

Adequacy of School Training:
Circle One Number for Each Item Listed

1. Unsatisfactory
2. Less Than Adequate
3. Adequate
4. More Than Adequate
5. Much More Than Adequate

Skill or Knowledge Item						
(Fact)	Identify Purposes and Organization of Personnel Qualification Standards	1	2	3	4	5
(Category)	Recognize Symptoms of Severe Electric Shock	1	2	3	4	5
(Procedure)	Operate Ship's Store Cash Register	1	2	3	4	5
(Rule)	Develop Drawing Layout for Sheet Metal Projects	1	2	3	4	5
(Principle)	Troubleshoot Magnetic Amplifiers	1	2	3	4	5

The task statements shown in table 3 are typical of those used on TAS questionnaires. However, the particular statements in the table represent tasks of five different ratings. They were deliberately chosen to provide examples of the five generic task types. The classification names shown in parentheses in the table do not appear on TAS questionnaires.

Listings of tasks taught at each school studied and supervisor ratings of training adequacy for these tasks were obtained from CNET. The questionnaire task statements for each school were classified by appropriate school SMEs into the generic task categories described earlier. This procedure permitted supervisor training adequacy ratings to be compiled for specific generic tasks. These data were then used for making "task-type" comparisons within and between courses.

Two different criterion measures were formed from the TAS fleet supervisor ratings for use in study analyses. One measure consisted of a mean TAS rating for each graduate involved in the study. Mean TAS ratings (for each graduate) were derived from the sum of all ratings assigned a given graduate divided by the number of questionnaire items for which the graduate's supervisor assigned a rating. The second measure used was a task-specific TAS rating. Task-specific TAS ratings consisted of mean ratings for each generic task. The task-specific ratings were derived by summing the ratings pertaining to a given generic task and dividing by the number of ratings pertaining to that given type of task.

Training Efficiency Measures. Measures used to reflect training efficiency were training costs and student time (contact hours of instruction) to complete a course.

Training cost data were available in the CNET Per Capita Cost Data Base for each course in the study. The training cost data were referenced to fiscal year 1979 which coincided with the time period that most graduates of interest to the study were in training. From the cost data base, a "training cost to produce one graduate per course session" was derived and used in subsequent analyses. Appendix D explains the derivation of training cost data.

Student course completion times were available for individualized courses from CMI files and from class records at the schools for self-paced courses. Completion times for the conventional courses were obtained from the schools and from CNET computer files.

STUDY SAMPLES

Two sets of samples were required for the study. The first consisted of courses taught under each of the basic methods of instruction, the second of graduates of these courses.

COURSE SAMPLES. The TAEG project staff coordinated with CNET and Chief of Naval Technical Training (CNTECHTRA) staff to select courses. The plan was to identify approximately 10 A-level courses that used CI (i.e., group-paced) and 10 others that used II (i.e., self-paced or computer managed). Courses in each instructional category were to include the full range of ability levels of individuals who undergo Navy technical training. It was also desired that courses in each category be roughly matched on general instructional content (i.e., type training tasks) and on geographic location.

Initial selection of courses for inclusion in the method of instruction groups was made on the basis of entries in the Navy Integrated Training Resources and Administrative System (NITRAS). This system identifies courses that are considered to be individualized (SP or CMI) and those considered to be taught conventionally (GP).

Courses selected for the study were primarily those classified as A-level. A-level courses provide basic skill and knowledge training for entry level Navy jobs. These courses were selected rather than C-level courses because:

- a greater diversity of tasks is trained in the more general A-level courses than in the largely equipment-specific C-level courses
- a wider range of student abilities is involved in A-level training
- proportionately more A-level courses are taught under II.

It was further desired that courses be selected to the extent possible from those for which TAS data were already available or soon to be available (i.e., within approximately the next 6 months). Although training appraisal schedules could be altered, this would have resulted in lengthy time delays to obtain data on course graduates. Consequently, availability of the TAS data became the major determinant of the sample composition. It is believed, however, that the other criteria were reasonably well met and that the courses constituted a representative sample of Navy "A" schools. The course samples are shown in table 4. The complete names of the courses and school locations are provided in appendix E.

Twenty-three A-level courses were included in the overall study. Nine self-paced and two CMI courses were in the II group. Eleven group-paced courses were in the CI group. One Hull Technician course was conducted using mixed instructional methods. Two officer courses were also selected for study. The content of the courses, Damage Control Assistant, was ostensibly the same but each course was taught under a different method of instruction. In addition, data were obtained from two basic CMI courses. Graduates of the RM Sea "A" School and the RM Shore "A" School also attended the RM Basics course. Their records were obtained from CNTECHTRA CMI files and used in analyses of interest to the study. Similarly, graduates of the EN, MM 600 psi, and MM 1200 psi schools attended the Propulsion Engineering (PE) Basics course prior to entry into their respective "A" schools. Their records were also obtained from CMI files.

GRADUATE SAMPLES. As mentioned previously, the names of school graduates who were included in the NAVEDTRACOM TAS graduate samples were obtained from CNET. Table 5 shows the numbers of graduates for each school for whom TAS records were obtained. Over all of the schools studied, a total of 7,083 graduate records were examined (5,278 for the schools shown in the table plus 1,805 records for those school graduates who first attended CMI basic courses before entering an "A" School). The table also shows the method of instruction used at each school and the inclusive graduation dates for the students. The numbers of graduates of each school for whom data were available on variables of interest are also shown. Note that some individualized courses give students an end-of-course grade while others do not. In some instances, the end-of-course grade is given based on a comprehensive examination; in others, it represents some combination of module test scores.

TABLE 4. COURSE SAMPLES

Self-Paced	Group-Paced
Damage Control Ass't (Phila)[1]	Damage Control Ass't (T.I.)[1] (DCA)
Hull Technician II (Phila) (HT)	Hull Technician I (T.I.) (HT)
Machinist's Mate, 600 psi[3] (MM6)	Hull Technician I (Phila) (HT)
Machinist's Mate, 1200 psi[3] (MM12)	Radioman, Sea[2] (RM)
Instrumentman (IM)	Radioman, Shore[2] (RM)
Training Device Repairman (TD)	Electrician's Mate (EM)
Personnelman (PN)	Fire Control Technician (FT)
Yeoman (YN)	Gunner's Mate (GM)
Disbursing Clerk (DK)	Av'n Support Eq. Tech (ASE)
Aviation Storekeeper (AK)	Av'n ASW Operator (AW)
	Ship's Serviceman (SH)
	Aviation Electrician's Mate (AE)
CMI	**Mixed**
Engineman[3] (EN)	Hull Technician II (S.D.) (HT)
Av'n Machinist's Mate (AD)	

[1] Officer Course

[2] Also obtained data from CMI RM basics course

[3] Also obtained data from CMI PE basics course

TABLE 5. GRADUATE SAMPLES

Course	Type	Graduating Dates	Original Sample Size	ASVAB	Time to Complete	End of Course Grade	Ratings on TAS Items
AK	SP	10/79-4/80	254	241	231	0	170
DCA (Phila)	SP	10/79-3/80	60	0	59	54	43
DK	SP	8/79-2/80	110	107	110	110	79
HT2 (Phila)	SP	10/78-3/79	319	318	294	303	218
IM	SP	10/79-4/80	18	18	17	16	15
MM 600	SP	10/78-3/79	374	372	284	282	138
MM 1200	SP	9/78-3/79	204	203	176	176	124
PN	SP	11/78-5/79	84	74	69	0	65
TD	SP	1/79-7/79	185	179	185	0	162
YN	SP	11/78-5/79	222	208	211	0	174
AD	CMI	10/79-4/80	464	450	454	464	98
EN	CMI	3/79-6/79	359	356	349	244	192
HT2 (San Diego)	MIXED	10/78-4/79	264	260	261	190	171
AE	GP	3/79-5/79	90	86	90	90	54
ASE	GP	8/79-2/80	36	29	36	36	29

TABLE 5. GRADUATE SAMPLES (continued)

Course	Type	Graduating Dates	Original Sample Size	ASVAB	Time to Complete	End of Course Grade	Ratings on TAS Items
AW	GP	1/79-7/79	47	42	45	45	35
DCA (Treasure Island)	GP	10/79-4/80	46	0	46	46	37
EM	GP	8/78-2/79	362	354	349	306	262
FT	GP	10/78-4/79	77	77	66	66	34
GM	GP	7/79-12/79	47	47	47	47	21
HT1 (Phila)	GP	10/78-3/79	319	318	319	0	218
HT1 (Treasure Island)	GP	10/78-4/79	264	260	198	197	171
RM-Sea	GP	2/79-12/79	496	495	487	0	369
RM-Shore	GP	3/79-8/79	400	397	400	0	396
SH	GP	10/79-3/80	177	176	177	177	132
Subtotals:	SP	10/78-4/80	1830	1720	1636	941	1188
	CMI	3/79-4/80	823	806	803	708	290
	Mixed	10/78-4/79	264	260	261	190	171
	GP	8/78-4/80	2361	2281	2260	1010	1758
Total		8/78-4/80	5278	5067	4960	2849	3407

DATA COLLECTION

The names, graduation dates, and social security numbers of school graduates were obtained from NAVEDTRACOM TAS files. Visits were made to the 25 schools between August and November 1980 to obtain data on course graduates. At the schools, data were manually recorded from class records and entered on worksheet forms for subsequent entry into computer files. Data recording was accomplished either by TAEG project staff or school SMEs functioning under general TAEG supervision. Information recorded consisted principally of end-of-course grades and time-to-complete training. Where available, other measures of training effectiveness/efficiency were also recorded. These other measures included numbers of academic remediations and setbacks, and numbers of additional hours of instruction required. Training cost data relevant to each course were obtained from CNET.

Training adequacy ratings and questionnaire task statements were obtained from the CNET TAS data base. The data included the fleet supervisors' TAS ratings for each graduate (i.e., 1, 2, 3, 4, or 5) on each skill/knowledge item of the course feedback questionnaire. The 12 ASVAB subtest scores of each graduate were also obtained from the CNET TAS data base (or the student master file when necessary). During school visits, assigned SMEs (3 to 5 at each school) classified the items on the TAS questionnaires into the generic task categories. This was done under general TAEG supervision and under the guidance presented in appendix C. Subject matter expert classifications were also entered into the data base. All data collection was completed by mid-1981.

DATA ANALYSIS

Analyses of training effectiveness and training efficiency were conducted on four different groupings of the courses in the study. These groupings are shown in table 6.

The first analysis was based on data of 19 single-phase enlisted "A" schools. The purpose of this analysis was to investigate possible differences between CI and II across courses as well as to assess interrelationships with the two other predictor variables (i.e., student ability level and type training task).

Data concerning two dual-phase enlisted "A" Schools were used in the second analysis. In these schools, enlisted personnel received a different method of instruction in each phase of the "A" School. A major purpose of the second analysis was to investigate the possibility of transfer effects between methods of instruction within the same group of graduates.

The third analysis was on data of two single-phase officer courses. Both officer courses nominally present the same subject matter but each under a different method of instruction. Thus, the purpose of the third analysis was to investigate possible differences in methods of instruction between the two officer courses when training content is held "constant."

Data obtained from all the courses included in the previous three analyses plus the two basic, pre-"A" School courses were used for the fourth analysis.

TABLE 6. COURSES INCLUDED IN THE FOUR ANALYSES

First Analysis			Second Analysis				Third Analysis				Fourth Analysis		
Name	N	Type	Name	CDP	N	Type	Name	CDP	N	Type	Name	N	Type
AD	464	CMI	HT2	6339	319	SP	DCA	3214	46	GP	All courses in previous analyses plus		
EN	359	CMI	HT1	6120	319	GP							
AK	254	SP	HT1	6119	264	GP	DCA	3218	60	SP	RM Basics	894	CMI
DK	110	SP	HT2	6106	264	SP+GP					PE Basics (EN)	359	CMI
IM	18	SP									PE Basics (MM)	552	CMI
MM6	374	SP											
MM12	204	SP											
PN	84	SP											
TD	185	SP											
YN	222	SP											
AE	90	GP											
ASE	36	GP											
AW	47	GP											
EN	362	GP											
FT	77	GP											
GM	47	GP											
RMSE	496	GP											
RMSH	400	GP											
SH	177	GP											

The purpose of the fourth analysis was to provide an in-depth investigation of training efficiency and/or effectiveness within each course studied.

The present report addresses only the results of the first analysis. The results of the other analyses will be presented in subsequent TAEG reports which are in preparation.

STATISTICAL MODEL. A partial hierarchical regression model was employed to examine the effects of each set of predictors on the criterion variables (Cohen & Cohen, 1975; Kim & Kohout, 1975). This model allowed a unique partitioning of the total variance of each criterion to be accounted for by each subset of predictors entered into the regression equation. The use of a multiple regression technique is consonant with current methodological approaches in investigating aptitude-treatment interactions (Cronbach & Snow, 1977). For the present TAEG study, predictor variables were considered statistically significant and relevant if: (1) they met an acceptable level of significance ($p < .05$) and (2) provided additional explanation of the variance of the criterion variable (increment the R^2 by 2 percent). For each criterion variable, an overall regression analysis was first performed. Then, individual comparisons were made on the variables. See appendix F for specification of the hierarchical regression model used in the study.

MISSING DATA ANALYSIS. Before proceeding with specific investigations of relationships among the variables of interest, a missing data analysis was conducted. This was done to determine if the sample of II and CI graduates for whom criterion data were available differed significantly from the sample for whom criterion data were absent. Although the results of the missing data analysis indicated overall differences based on method of instruction, ability level, and training task, no significant interactions were found (see appendix G). Thus, graduates for whom data on end-of-course grades, time-to-complete, and TAS ratings were present did not differ in any combination of background characteristics (e.g., ability level by method of instruction) from those graduates who had no data present on the criterion variables.

SECTION III

RESULTS

The results of the study are provided in this section. All results are based on data analyses conducted across 19 different "A1" schools/courses. Ten of the courses were individualized (eight SP, two CMI) and nine were group-paced. The specific courses examined were identified in table 6 (under the column, "first analysis"). The original sample sizes (N) of graduates trained under each instructional method are given in table 7.

TABLE 7. ORIGINAL SAMPLE SIZES OF GRADUATES

Method of Instruction	N	
Individualized (SP + CMI)		2274
Self-Paced (SP)	1451	
Computer Managed Instruction (CMI)	823	
Conventional (GP)		1732
Group-Paced (GP)	1732	
Total		4006

In this section, a relatively large number of tables and figures are used. These are necessary to display adequately the study findings and to present the supporting statistical evidence for the many significant relationships observed among the variables of interest. All significant findings are shown, however, in three tables presented at the end of the section (tables 35, 36, and 37). In the main body of the section, the results are organized according to the format described immediately below.

All results are presented in order of the criterion variables examined; i.e., the measures of training effectiveness and training efficiency. For each criterion measure, tables are presented to summarize the significant results of overall regression analyses. Each summary table for a criterion measure identifies the predictors assessed and lists the regression coefficients (B) and F-ratios (F) obtained. The summary tables also show the degrees of freedom (DF) involved in specific comparisons and the magnitude of a particular R^2 increment. The numbers listed under "step" in the summary tables refer to the order in which that particular set of predictor variables was entered into the regression equation (see appendix F).

As mentioned above, the statistical summary tables identify the significant results relative to a given criterion variable. After the summary tables, each significant predictor, both main effects and interactions, is further delineated separately. Supporting data for the significant results are presented in tables. For each criterion variable, nonsignificant results are grouped together in one paragraph. Note that in the main effects analyses, data concerning a particular criterion variable are combined over all courses and over all graduates. The purpose of the main effects analyses is to assess the contribution to criterion variance of one particular predictor variable (e.g., method of instruction, trainee ability). For the present study, the interpretation of significant main effects should be tempered by a significant interaction of that main effect with another predictor variable.

TRAINING EFFECTIVENESS MEASURES

The criterion measures of training effectiveness were end of course grades and TAS ratings. Two variables were formed from the TAS ratings: overall mean TAS ratings and task-specific TAS ratings.

CRITERION: END-OF-COURSE GRADES. End-of-course grades represent the average percent correct obtained by a graduate on items tested in the school. End-of-course grades obtained from the schools were based on either combinations of scores from module/lesson examinations administered during the course of training, or on comprehensive examinations administered at the end of training. The overall results of regression analyses of end-of-course grades are presented in table 8. Significant and nonsignificant results are further detailed below.

Method of Instruction. Graduates of individualized courses (SP + CMI) received higher end of course grades than CI (GP) graduates. SP graduates received higher end of course grades than CMI graduates (see table 9).

Ability Level. Across all II and CI courses, graduates with higher AFQT percentile scores received higher end of course grades than those with lower scores (see table 10).

Method of Instruction by Ability Level. Individualized instruction (SP + CMI) graduates at the higher AFQT percentiles received higher end of course grades than CI (GP) graduates at the higher percentiles. Lower ability II and CI graduates received similar end of course grades. Conventional instruction graduates at higher AFQT percentiles received end of course grades similar to those of CI graduates at the lower AFQT percentiles. For both SP and CMI graduates, AFQT was positively related to end of course grade. Both SP and CMI graduates had similar positive relationships between end of course grades and ability level (see figure 1 and table 11).

Training Task. Across II and CI courses, end of course grades were higher in courses that taught a larger percentage of category, procedure, and rule tasks than in courses that taught a lesser percentage of these tasks. End of course grades were higher in II and CI courses that taught a smaller percentage of fact and principle tasks than in courses that taught a larger percentage of these tasks (see table 12).

TABLE 8. SIGNIFICANT RESULTS FROM REGRESSION ANALYSES OF END-OF-COURSE GRADES

Step	Variables	B	F	DF	R^2 Increment	Overall F	DF
1	II vs CI (T1)	-4.13	376.72	1/2041	.2034	260.64	2/2041
	SP vs CMI (T2)	-2.55	169.41	1/2041			
2	AFQT (A)	.13	188.95	1/2036	.2041	140.29	5/2036
	Fact (I1)	-.60	175.31	1/2036			
	Category (I2)	.28	151.58	1/2036			
	Procedure (I3)	.13	141.29	1/2036			
	Rule (I4)	.10	92.31	1/2036			
3	T1 x I1	2.27	49.73	1/2031	.0831	66.27	5/2031
	T1 x I3	-.30	133.95	1/2031			
	A x T1	-.04	13.07	1/2031			

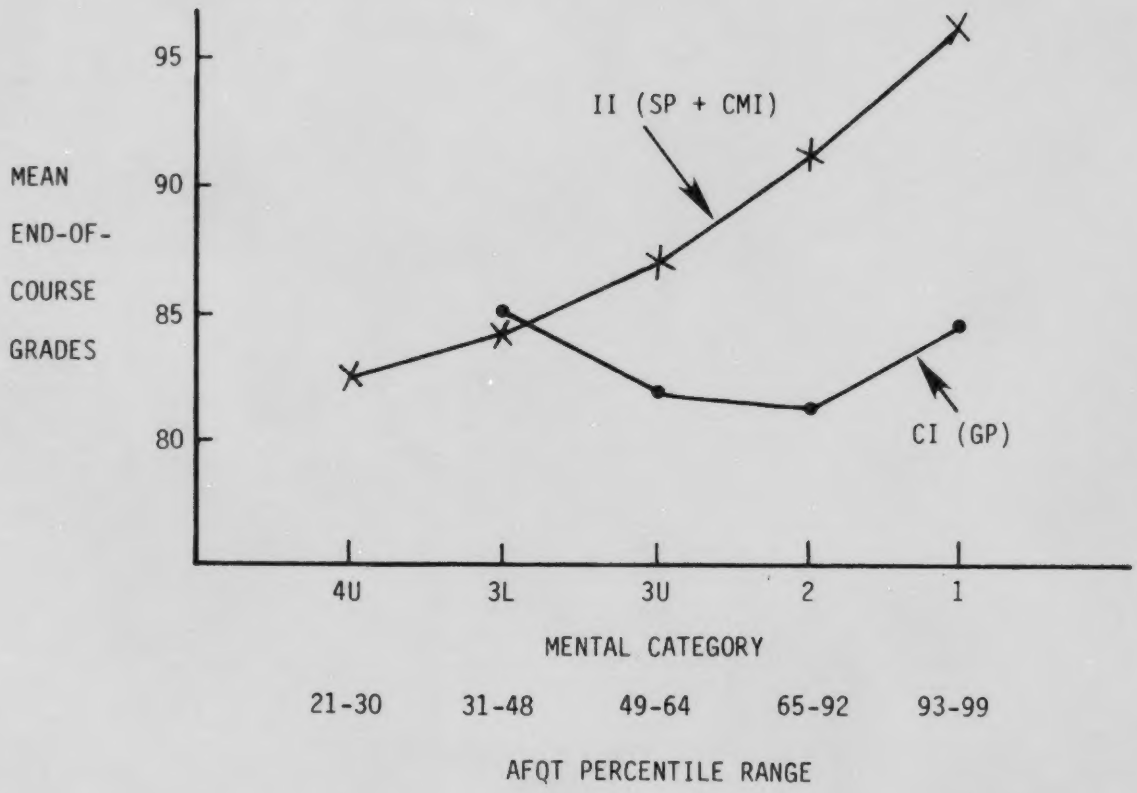
TABLE 9. END-OF-COURSE GRADES BY METHOD OF INSTRUCTION

Method of Instruction	Mean	SD*	N
SP	90.84	5.51	584
CMI	85.74	8.24	692
II (SP + CMI)	88.08	7.56	1276
CI (GP)	82.10	6.72	768

*Standard Deviation

TABLE 10. END-OF-COURSE GRADES BY AFQT PERCENTILE RANGE AND MENTAL CATEGORY

AFQT Percentile Range	Mental Category	Mean	SD	N
93-99	1	92.68	6.51	135
65-92	2	87.45	7.63	673
49-64	3U	84.55	7.32	737
31-48	3L	83.58	7.63	436
21-30	4U	81.87	7.83	21
10-20	4L	79.50	0.0	1



Note: Mean data points based on less than five cases are not plotted.

Figure 1. Mean End-of-Course Grades by Method of Instruction and Ability Level

TABLE 11. END-OF-COURSE GRADES BY METHOD OF INSTRUCTION AND ABILITY LEVEL

AFQT Percentile Range	Mental Category	Method of Instruction	Mean	SD	N
93-99	1	SP	95.50	3.04	102
		CMI	92.69	9.16	2
		SP + CMI	95.44	3.17	104
		GP	83.41	6.30	31
65-92	2	SP	91.96	4.95	273
		CMI	90.38	6.13	140
		SP + CMI	91.42	5.43	413
		GP	81.33	6.24	260
49-64	3U	SP	87.29	4.64	146
		CMI	86.42	7.99	263
		SP + CMI	86.73	6.98	409
		GP	81.83	6.80	328
31-48	3L	SP	86.38	4.79	58
		CMI	82.81	8.27	253
		SP + CMI	83.47	7.86	311
		GP	83.84	7.05	125
21-30	4U	SP	0	0	0
		CMI	82.12	7.95	20
		SP + CMI	82.12	7.95	20
		GP	77.07	0	1
10-20	4L	GP	79.05	0	1

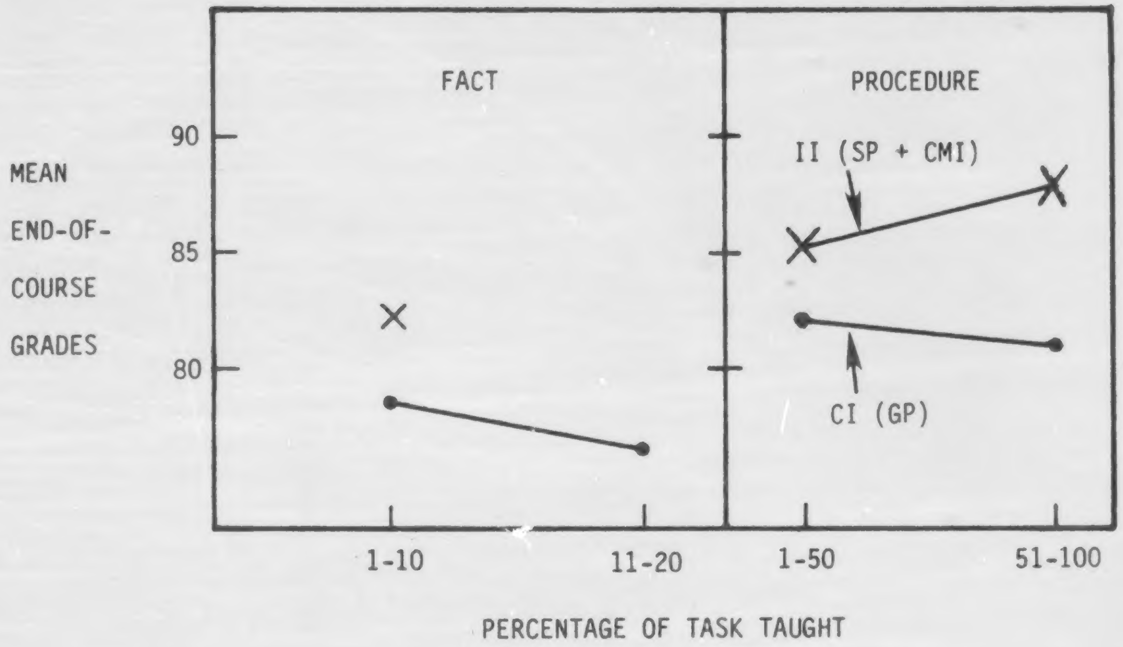
TABLE 12. END-OF-COURSE GRADES BY PERCENTAGE OF TASK TRAINED

Task	Percent	Mean	SD	N
Fact	1-15	81.35	6.66	852
	16-30	77.69	4.79	66
Category	1-15	84.92	5.32	859
	16-30	89.02	5.52	680
Procedure	1-50	82.94	5.03	721
	51-100	87.41	6.30	1323
Rule	1-50	82.47	6.21	1237
	51-100	86.08	4.89	110
Principle	1-50	87.98	4.82	936
	51-100	79.36	5.35	306

Method of Instruction by Training Task. Individualized instruction graduates received higher grades in courses that taught a smaller percentage of fact tasks than CI graduates in courses that taught a smaller percentage of fact tasks. There were no data points from II courses for a larger percentage of fact tasks on which to base a comparison with CI courses. Individualized instruction graduates received higher grades in courses that taught a larger percentage of procedure tasks than II graduates who were taught a smaller percentage of procedure tasks. Conventional instruction graduates received similar grades in courses that taught smaller and larger percentages of procedure tasks (see figure 2 and table 13).

TABLE 13. END-OF-COURSE GRADES BY PERCENTAGE OF TYPE OF TRAINING TASK AND METHOD OF INSTRUCTION

Task	Percentage Range	Method	Mean	SD	N
Fact	1-10	II	83.08	7.65	453
		CI	79.39	5.44	399
	11-20	II	0	0	0
		CI	77.69	4.80	66
Procedure	1-50	II	85.65	5.07	126
		CI	82.37	5.11	595
	51-100	II	88.34	7.04	1150
		CI	81.19	6.17	173



Note: Mean data points based on less than five cases are not plotted.

Figure 2. Mean End-of-Course Grades by Method of Instruction and Training Task

Nonsignificant Results. The interactions of ability level by training task, and ability level by training task by method of instruction did not significantly predict end-of-course grades. The main effects for sex of graduate and geographic location of school were also not significant.

CRITERION: OVERALL TRAINING APPRAISAL SYSTEM (TAS) RATINGS. For this analysis, a mean (overall) TAS rating was computed for each course graduate. The means were derived from supervisor ratings of the graduate on individual TAS questionnaire items. Significant results obtained from the overall regression analyses are presented in table 14. Specific findings are listed below.

TABLE 14. SIGNIFICANT RESULTS FROM REGRESSION ANALYSES OF OVERALL TRAINING ADEQUACY RATINGS

Step	Variables	B	F	DF	R^2 Increment	Overall F	DF
1	II vs CI (T1)	-0.16	62.36	1/2412	.0267	33.10	2/2412
2	Fact (I1)	0.01	4.23	1/2407	.0378	19.46	5/2407
	Category (I2)	-0.02	81.74	1/2407			

Method of Instruction. Individualized instruction (SP + CMI) graduates received higher mean TAS ratings than CI (GP) graduates. There were no significant differences between SP and CMI graduates on mean TAS ratings (see table 15).

TABLE 15. OVERALL TAS RATINGS BY METHOD OF INSTRUCTION

Method of Instruction	Mean	SD	N
SP	2.90	.70	899
CMI	2.96	.57	287
II (SP+CMI)	2.91	.67	1186
CI (GP)	2.69	.67	1229

Training Task. Across II and CI courses, graduates who attended those courses that taught a smaller percentage of fact or category tasks received higher average TAS ratings than graduates who were taught a greater percentage of these tasks (see table 16).

TABLE 16. TAS RATINGS BY TYPES OF TASKS

Task	Percentage of Task Taught	Mean	SD	N
Fact	1-10	2.86	.56	408
	11-20	2.73	.64	34
Category	1-10	2.92	.66	1027
	11-20	2.66	.69	1149
	21-30	2.73	.64	34

Nonsignificant Results. All interactions involving combinations of ability level, method of instruction, and training task did not significantly predict mean TAS ratings. The following main effects were also nonsignificant: ability level, end-of-course grade, time-to-complete the course, sex of graduate, and geographic location of school.

CRITERION: TASK-SPECIFIC TAS RATINGS. TAS ratings were also grouped by items classified into generic tasks (i.e., facts, categories, procedures, rules, and principles). Then, mean TAS ratings were computed for each of the generic task groupings. These groupings and resulting means permitted task-specific TAS ratings to be regressed on a specific task, and on ability level, method of instruction, and their interactions. One purpose of this analysis was to determine if the percentage of a particular task trained in "A" School was related to the ratings obtained on TAS items classified as that particular task. This permitted answering questions of the form, "Are higher TAS ratings on items classified as, e.g. fact tasks, associated with a larger percentage of, e.g. fact tasks, taught in 'A' School?" This analysis would clarify if specific training content in the school setting transfers to the fleet (operational) setting (as reflected in the task-specific TAS ratings). Another purpose was to assess the interactions of specific tasks with trainee ability level and method of instruction.

Significant results of the regression analyses for all task-specific TAS ratings are presented in table 17. Then, the results of these analyses are further delineated below according to the generic task to which the TAS ratings apply (criterion variables).

Criterion: Fact TAS Ratings. Percentage of fact task trained, AFQT percentile, method of instruction, and the interactions of these variables did not significantly predict fact TAS ratings.

TABLE 17. SIGNIFICANT RESULTS FROM REGRESSION ANALYSES OF TASK-SPECIFIC TAS RATINGS

Criterion	Step	Variable	B	F	DF	R^2 Increment	Overall F	DF
Category	2	Category (I2)	-.02	55.20	1/1703	.0309	27.58	2/1703
Procedure	3	T1 x I3*	-.01	75.53	1/2336	.0334	27.73	3/2336
Rule	3	T1 x I4**	-.02	31.20	1/228	.0297	12.64	3/1228
		A x T2***	.01	5.01	1/228			
Principle	1	T1****	.15	19.14	1/871	.0215	19.14	1/871

*T1 x I3 = Method of instruction by procedure task interaction.
**T1 x I4 = Method of instruction by rule task interaction.
***A x T2 = AFQT by method of instruction (SP vs CMI) interaction.
****T1 = II vs CI.

Note: No significant results for fact TAS ratings.

Criterion: Category TAS Ratings.

Percentage of Category Task Trained. Across II and CI courses, graduates who were presented with a smaller percentage of category tasks during training received higher category-specific TAS ratings than graduates presented with a larger percentage of category tasks during training (see table 18).

TABLE 18. CATEGORY-SPECIFIC TASK RATINGS BY PERCENTAGE OF CATEGORY TASKS TRAINED

Percentage of Category Task	Mean	SD	N
1-15	3.10	.63	1055
16-30	2.70	.63	583

Nonsignificant Results. AFQT percentiles, method of instruction, and their interactions with percentage of category task trained did not significantly predict category TAS ratings.

Criterion: Procedure TAS Ratings.

Method of Instruction by Percentage of Procedure Task Trained. Conventional instruction graduates who were presented with a smaller percentage of procedure tasks during training received higher procedure-specific TAS ratings than II graduates presented with a smaller percentage of procedure tasks. On the other hand, II graduates who were presented with a larger percentage of procedure tasks during training received higher procedure-specific TAS ratings than CI graduates presented with a larger percentage of procedure tasks during training (see figure 3 and table 19). Percentage of procedure task taught was positively related to procedure TAS ratings for II graduates and negatively related for CI graduates. There were no significant differences between SP and CMI graduates on procedure TAS ratings.

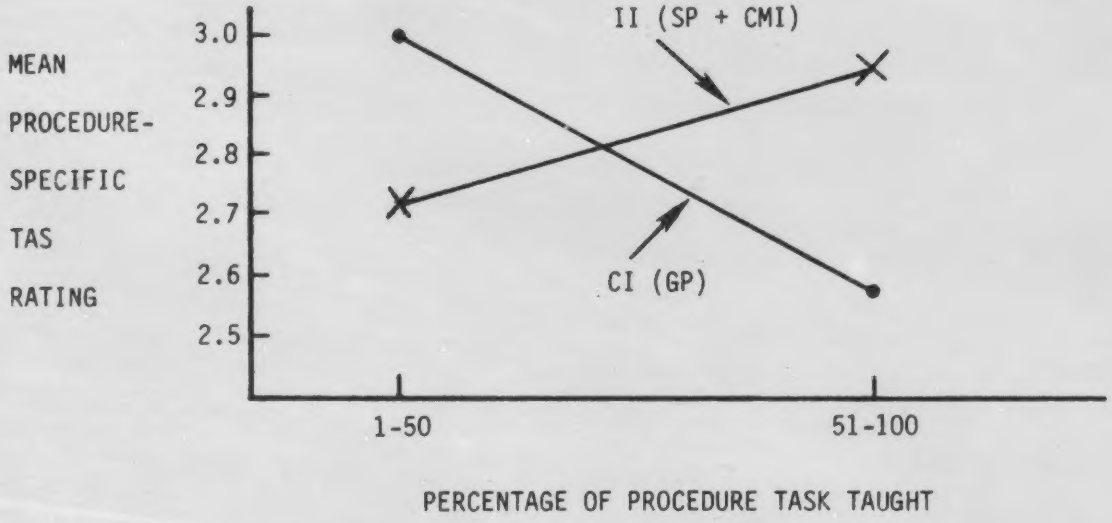


Figure 3. Mean Procedure TAS Ratings by Percentage of Procedure Task Taught and Method of Instruction

TABLE 19. PROCEDURE-SPECIFIC TAS RATINGS BY PERCENTAGE OF PROCEDURE TASK TRAINED AND METHOD OF INSTRUCTION

Percentage of Procedure Task	II			CI		
	Mean	SD	N	Mean	SD	N
1-50	2.71	.70	209	3.00	.73	462
51-100	2.95	.68	920	2.55	.63	753

Nonsignificant Results. AFQT percentile, percentage of procedure tasks trained, method of instruction, and their remaining interactions did not significantly predict procedure-specific TAS ratings.

Criterion: Rule TAS Ratings.

Method of Instruction by Percentage of Rule Task Trained. Individualized instruction graduates who were presented with a smaller percentage of rule tasks during training received higher rule-specific TAS ratings than CI graduates presented with a smaller percentage of rule tasks during training. On the other hand, CI graduates who were presented with a larger percentage of rule tasks during training received higher rule-specific TAS ratings than II graduates presented with a larger percentage of rule tasks during training. Percentage of rule task was negatively related to rule TAS ratings for II graduates and positively related for CI graduates (see figure 4 and table 20). There were no significant differences between SP and CMI graduates on Rule TAS ratings.

Method of Instruction by Ability Level. Higher ability CMI graduates received higher rule-specific TAS ratings [illegible] higher ability SP and GP graduates. Average to lower ability SP and G[illegible] gr[illegible]uates received rule-specific TAS ratings similar to those received by average to lower ability CMI graduates. There were no significant differences between II (SP and CMI combined) and CI (GP) graduates on rule-specific TAS ratings by ability level (see figure 5 and table 21).

Nonsignificant Results. Percentage of training task, AFQT percentiles, method of instruction, and their remaining interactions did not significantly predict rule-specific TAS ratings.

Criterion: Principle TAS Ratings.

Method of Instruction. Conventional instruction (GP) graduates received higher principle- specific TAS ratings than II (SP and CMI) graduates. There were no significant differences between SP and CMI graduates on principle-specific TAS ratings (see table 22).

Nonsignificant Results. Percentage of principle tasks trained, ability level, and their interactions did not significantly predict principle-specific TAS ratings.

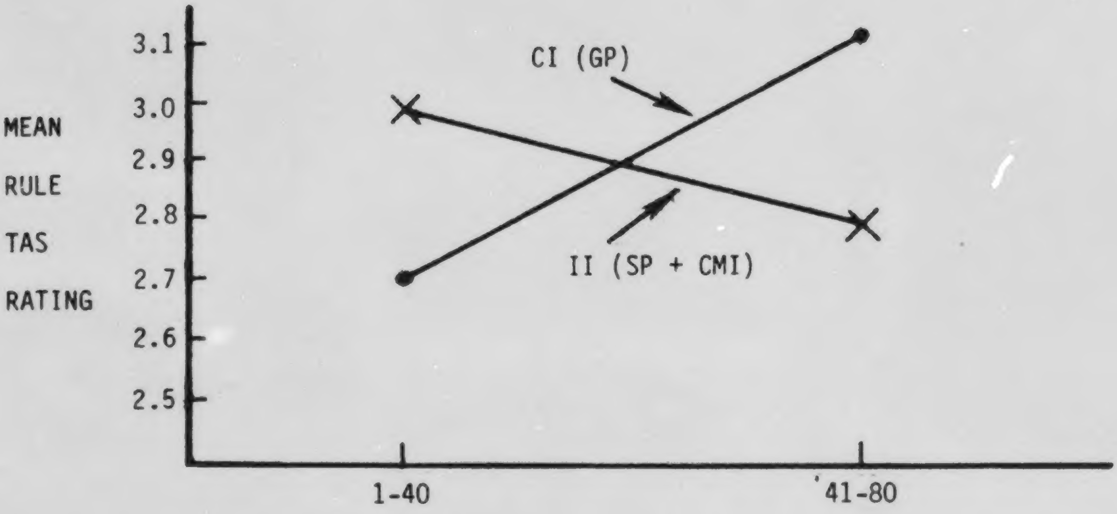
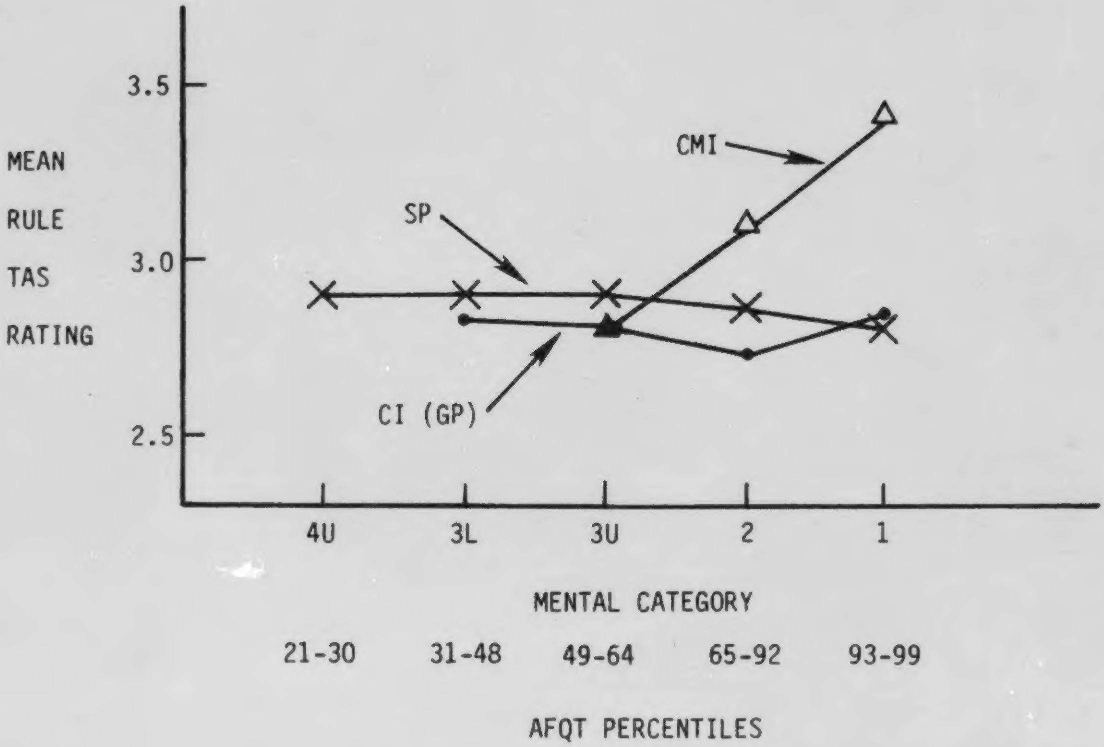


Figure 4. Mean Rule TAS Rating by Percentage of Rule Task Taught and Method of Instruction

TABLE 20. RULE-SPECIFIC TAS RATINGS BY PERCENTAGE OF RULE TASK TRAINED AND METHOD OF INSTRUCTION

Percentage of Rule Task	II			CI		
	Mean	SD	N	Mean	SD	N
1-40	3.00	.80	450	2.72	.67	417
41-80	2.80	.90	239	3.17	.52	130



Note: Mean data points based on less than five cases are not plotted.

Figure 5. Mean Rule TAS Rating by Ability Lev[illegible] and Method of Instruction.

TABLE 21. RULE-SPECIFIC TAS RATINGS BY ABILITY LEVEL
AND METHOD OF INSTRUCTION

		SP			CMI			GP		
AFQT Percentile	Mental Category	Mean	SD	N	Mean	SD	N	Mean	SD	N
93-99	1	2.84	.70	47	3.45	.93	11	2.89	.72	11
65-92	2	2.87	.74	220	3.10	.78	15	2.75	.73	188
49-64	3U	2.93	.74	218	2.85	.81	24	2.84	.70	235
31-48	3L	2.92	.86	107	3.0	--	1	2.86	.72	92
21-30	4U	2.93	.45	7	--	--	--	3.0	--	1
10-20	4L	--	--	--	--	--	--	4.0	--	1

TABLE 22. PRINCIPLE-SPECIFIC TAS RATINGS
BY METHOD OF INSTRUCTION

Method of Instruction	Mean	SD	N
II (SP + CMI)	2.59	.87	384
CI (GP)	2.82	.67	489

TRAINING EFFICIENCY MEASURES

The measures of training efficiency examined were time to complete the course and training costs. The results obtained concerning training efficiency are presented below.

CRITERION: TIME TO COMPLETE THE COURSE. Time to complete the course was represented by student contact hours. Student contact hours reflect the amount of time the student was under direct instruction. Significant results of the regression analyses performed are summarized in table 23. The results are further detailed below.

TABLE 23. SIGNIFICANT RESULTS FROM REGRESSION ANALYSES OF TIME TO COMPLETE (CONTACT HOURS) COURSES

Step	Variables	B	F	DF	R^2 Increment	Overall F	DF
1	II vs CI (T1)	28.14	157.41	1/3789	.0436	86.30	2/3789
	SP vs CMI (T2)	-13.34	33.89	1/3789			
2	AFQT (A)	- 0.70	73.86	1/3784	.4903	3979.38	5/3784
	Fact (I1)	12.89	700.34	1/3784			
	Category (I2)	- 5.96	1012.49	1/3784			
	Procedure (I3)	- 1.81	536.40	1/3784			
	Rule (I4)	- 0.79	67.98	1/3784			
3	T1 x I1	27.47	318.38	1/3778	.0659	163.67	6/3778
	T1 x I2	9.56	304.58	1/3778			
	T1 x I3	3.42	268.62	1/3778			
	T1 x I4	3.93	311.11	1/3778			
	A x T1	1.00	85.24	1/3778			
	A x T2	0.47	19.69	1/3778			

Method of Instruction. Individualized instruction (SP + CMI) graduates completed their courses in less time than CI (GP) graduates. Within the II group, CMI graduates completed their courses in less time than SP graduates (see table 24).

TABLE 24. TIME TO COMPLETE THE COURSE (CONTACT HOURS) BY METHOD OF INSTRUCTION

Method of Instruction	Mean	SD	N
SP	166.35	69.60	1283
CMI	139.57	88.25	803
II (SP+CMI)	156.04	82.57	2086
CI (GP)	195.22	122.05	1707

Ability Level. Across II and CI courses, graduates with higher AFQT percentile scores finished their courses in less time than those with lower AFQT percentile scores (see table 25). Graduates at the mid-AFQT percentiles had similar course completion times. These main effect findings are tempered, however, by the interaction analysis given below.

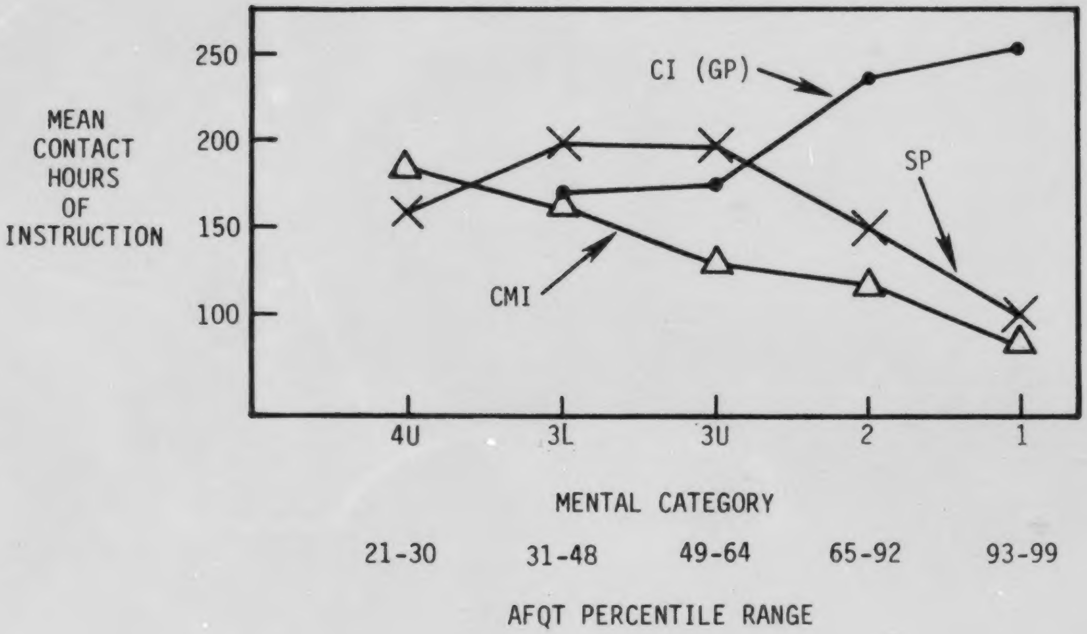
TABLE 25. TIME TO COMPLETE THE COURSE (CONTACT HOURS) BY ABILITY LEVEL

AFQT Percentile Range	Mental Category	Mean	SD	N
93-99	1	134.64	93.05	203
65-92	2	178.19	113.29	1114
49-64	3U	174.11	103.45	1551
31-48	3L	172.12	91.30	800
21-30	4U	191.73	83.40	34
10-20	4L	480.00	0.0	1

Method of Instruction by Ability Level. Individualized instruction graduates in the upper mental categories finished their courses in less time than corresponding CI graduates. Both II (SP + CMI) and CI (GP) graduates in the mid and lower mental categories took about the same amount of time to complete their courses (see figure 6 and table 26). Training time was negatively related to ability level for II graduates, and positively related for CI graduates. Training time was significantly less for CMI graduates than for SP graduates at each ability level except for the lowest ability level. SP graduates had significantly less training time than CMI graduates at the lowest ability level (mental category 4U).

Training Task. Across II and CI courses, student completion times were longer for courses that taught a greater percentage of fact or principle tasks than a lower percentage of these tasks. Student completion times were shorter in courses that taught a lower percentage of category, principle, or rule tasks than a higher percentage of these tasks (see table 27).

Method of Instruction by Training Task. Individualized instruction graduates had lower completion times in courses that taught a smaller percentage of fact, category, procedure, rule, or principle tasks than CI graduates taught a smaller percentage of these tasks. In addition, II graduates had lower completion times in courses that taught a larger percentage of category or procedure tasks than CI graduates taught a larger percentage of these tasks. For II graduates, course completion time was negatively related to the percentage of category or procedure tasks taught. There was no significant relationship between course completion time and percentage of rule tasks taught for II graduates. For CI graduates, course completion time was positively related to the percentage of fact tasks taught, but negatively related to the percentage of category, procedure, or principle tasks (see figure 7 and table 28).



Note: Mean data points based on less than five graduates are not plotted.

Figure 6. Mean Time to Complete the Course by Method of Instruction and Ability Level

TABLE 26. TIME TO COMPLETE (CONTACT HOURS) BY METHOD OF INSTRUCTION AND ABILITY LEVEL

AFQT Percentile	Mental Category	Method of Instruction	Mean	SD	N
93-99	1	SP	101.50	48.72	152
		CMI	83.33	38.67	6
		SP + CMI	100.83	48.39	158
		GP	253.31	113.53	45
65-92	2	SP	149.52	81.99	508
		CMI	115.65	61.08	167
		SP + CMI	141.14	78.71	675
		GP	235.16	133.08	439
49-64	3U	SP	199.59	82.33	390
		CMI	130.13	67.02	310
		SP + CMI	168.83	83.37	700
		GP	178.45	117.29	851
31-48	3L	SP	198.59	104.86	178
		CMI	161.25	69.87	281
		SP + CMI	175.73	86.98	459
		GP	167.25	96.73	341
21-30	4U	SP	155.20	43.06	10
		CMI	188.53	77.69	21
		SP + CMI	177.78	69.51	31
		GP	335.87	90.18	3
10-20	4L	GP	480.0	-	1

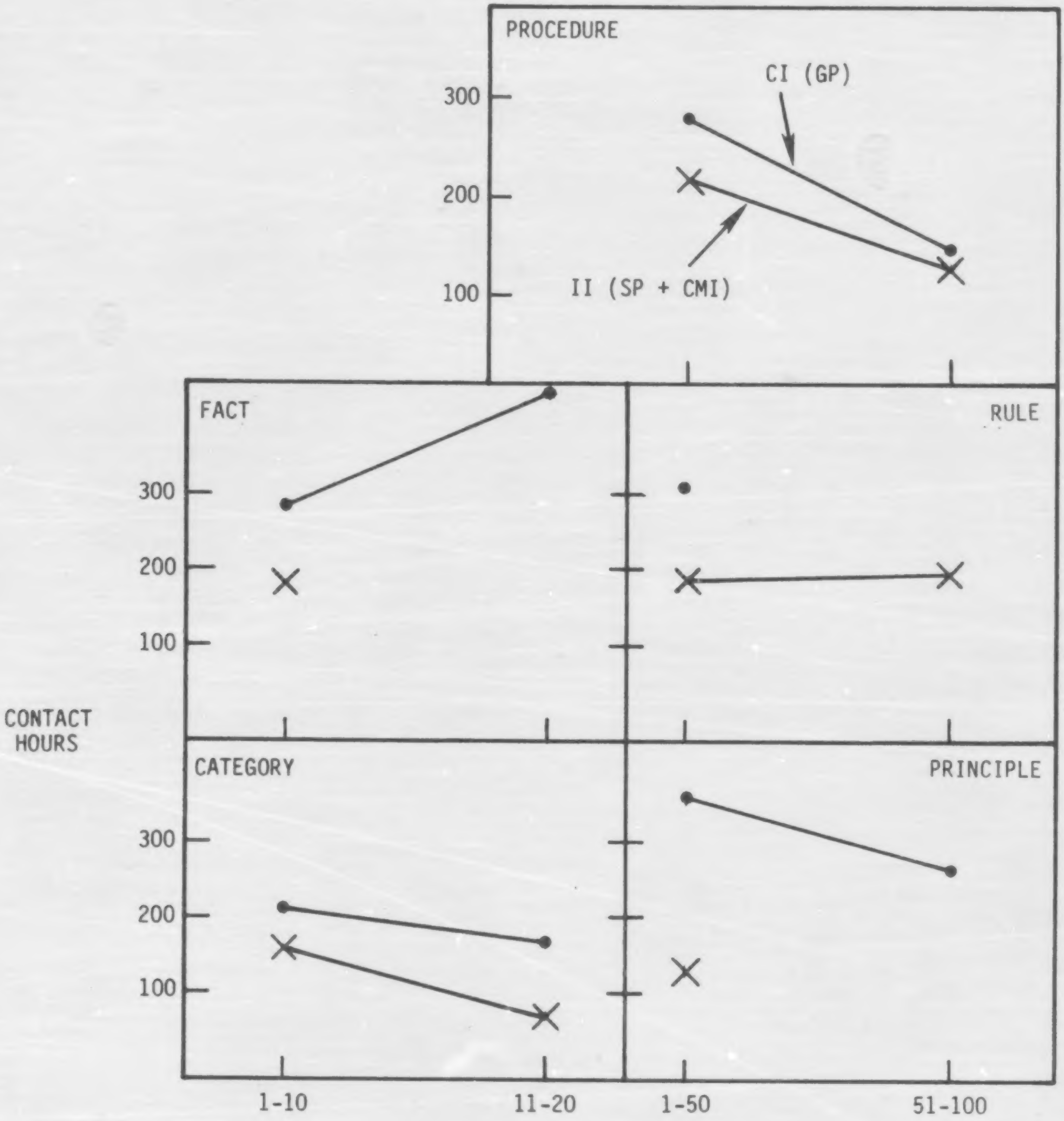


Figure 7. Mean Time to Complete the Course by Method of Instruction and Type Training Task

TABLE 27. TIME TO COMPLETE THE COURSE (CONTACT HOURS) BY PERCENTAGE OF TRAINING TASK

Percentage Ranges of Task Taught	Fact			Category			Procedure			Rule			Principle		
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
1-10	235.53	72.70	896	232.77	81.94	1353		N/A		245.83	124.71	874	207.62	70.10	398
11-20	428.03	50.53	66	108.45	68.75	1797	257.30	120.27	407	267.93	46.90	396	130.61	78.83	507
21-30		N/A		428.03	50.53	66	259.46	43.45	349	221.58	88.61	346	428.03	50.53	66
31-40		N/A			N/A			N/A			N/A		446.67	14.99	90
41-50		N/A			N/A		274.11	116.30	194	240.00	0	177	465.29	122.23	63
51-60		N/A			N/A		406.92	56.60	137		N/A		259.46	43.45	349
61-70		N/A			N/A		142.36	65.81	691		N/A			N/A	
71-80		N/A			N/A		116.65	23.61	565	196.12	74.67	295		N/A	
81-90		N/A			N/A		125.24	66.10	1413		N/A			N/A	
91-100		N/A			N/A		368.00	0	36		N/A			N/A	

TABLE 28. TIME TO COMPLETE (CONTACT HOURS) BY PERCENTAGE OF TASK TAUGHT AND METHOD OF INSTRUCTION

Task	Percentage of Task Taught	II			CI		
		Mean	SD	N	Mean	SD	N
Fact	1-15	190.12	50.46	454	282.16	39.84	442
	16-30	0	0	0	428.03	50.53	66
Category	1-15	160.71	43.15	1197	207.77	55.56	1062
	16-20	73.84	13.46	348	163.14	16.70	609
Procedure	1-50	219.72	45.39	312	281.97	33.52	638
	51-100	131.86	36.94	1773	143.45	10.31	1069
Rule	1-50	194.72	52.42	982	306.90	33.13	811
	51-100	196.12	35.28	295	0	0	0
Principle	1-50	133.34	43.00	662	342.73	22.38	462
	51-100	0	0	0	259.46	43.45	349

Nonsignificant Results. The interactions of ability level by training task, and ability level by training task by method of instruction; main effects of sex of graduate and geographic location of school did not significantly predict time to complete the course.

CRITERION: TRAINING COSTS. To conduct analyses of instructional costs, an individual training cost was computed for each graduate. This was derived by dividing a graduate's course completion time by average course completion time and then multiplying this quotient by the "average course training cost to produce one graduate per course session" (see appendix C). Computing individual training costs in this manner provided the variance needed within courses to conduct regression analyses with training costs as the criterion variable. If a graduate's course completion time was longer than the average course completion time, then his/her training cost would be greater than the average course training cost. If a graduate's course completion time was shorter than the average course completion time, then his/her training cost would be less than the average course training cost. Thus, the computation of individual training costs associated shorter course completion times for a graduate with less training costs.

The overall results of the regression analyses of training costs are presented in table 29. Significant and nonsignificant results, both main effects and interactions, are listed below.

Method of Instruction. Significantly higher training costs were associated with II (SP + CMI) graduates than with CI (GP) graduates. Training costs were significantly greater for SP graduates than for CMI graduates. Training costs were similar for CI (GP) and CMI graduates (see table 30). The apparent contradiction of higher training costs and lower training times

TABLE 29. SIGNIFICANT RESULTS FROM REGRESSION ANALYSES OF TRAINING COSTS

Step	Predictor	B	F	DF	R^2 Increment	Overall F	DF
1	II vs CI (T1)	-115.97	18.64	1/3789.	.0293	57.17	2/3789
	SP vs CMI (T2)	-246.45	80.70	1/3789			
2	AFQT (A)	- 10.85	98.38	1/3784	.3753	471.98	5/3784
	Fact (I1)	109.08	275.09	1/3784			
	Category (I2)	- 58.05	526.27	1/3784			
	Procedure (I3)	- 24.98	561.56	1/3784			
	Rule (I4)	- 15.57	146.52	1/3784			
3	A x T1	13.94	97.70	1/3778	.1177	153.10	1/3778
	A x T2	4.75	11.94	1/3778			
	T1 x I1	233.45	134.60	1/3778			
	T1 x I2	132.12	340.22	1/3778			
	T1 x I4	23.22	63.49	1/3778			
4	TICOM*	11.75	15418.92	1/3769	.3819	15419.18	1/3769

*Time to complete the course.

being associated overall with II graduates is further explained by the interaction of method of instruction by ability level.

TABLE 30. TRAINING COSTS BY METHOD OF INSTRUCTION

Method of Instruction	Mean	SD	N
SP	$ 2573.71	1102.36	1283
CMI	2080.81	705.78	802
II (SP + CMI)	2384.11	969.21	2085
CI (GP)	2153.31	1467.29	1707

Ability Level. Across II and CI courses, training costs were significantly greater for lower mental category graduates than for higher mental category graduates (see table 31). Training costs were similar for graduates at the middle mental categories. This main effect is also partitioned further by the interaction of method of instruction by ability level.

TABLE 31. TRAINING COSTS BY ABILITY LEVEL

AFQT Percentile Range	Mental Category	Mean	SD	N
93-99	1	$1982.57	1056.01	203
65-92	2	2370.01	1285.24	1114
49-64	3U	2207.48	1253.92	1551
31-48	3L	2285.47	1136.47	800
21-30	4U	2837.38	945.76	34
10-20	4L	4704.67	0	1

Method of Instruction by Ability Level. Training costs were significantly greater for mid to lower mental category II (SP + CMI) graduates than for mid to lower mental category CI (GP) graduates. On the other hand, training costs were significantly greater for upper mental category CI (GP) graduates than for upper mental category II (SP + CMI) graduates. Also, training costs were significantly greater for mid to lower mental category SP graduates than for mid to lower mental category CMI graduates. Training costs were similar for upper mental category SP and CMI graduates. Training costs were negatively related to ability level for II graduates and positively related for CI graduates (see figure 8 and table 32).

The explanation for the apparent contradiction--higher training costs but shorter training time for II graduates when longer training time is related to higher training costs over all courses--is inherent in the nature of the training cost variables used. When training costs are computed for individual graduates across all courses, students who take more time to complete their courses do indeed cost more to train than those who take less time to complete the course. This is due to the relationship of the average course costs being multiplied by the graduate's individual training time divided by the average course completion time. The result of this individual training cost metric is that slower students are assigned a training cost value greater than the average course cost and faster students are assigned a value lower than the average course cost. Thus, the individual training costs as computed in this study allow one to observe a positive relationship overall between training time and training cost. However, the average course costs represent given values from the CNET Per Capita Cost Data Base and, as such, may or may not be as dependent on course completion time as the individual training costs. The higher costs observed for the II courses in this study may be due to a course characteristic difference that may or may not be related to method of instruction. One way to clarify this issue would be to obtain and analyze the cost data of particular categories that make up the total training costs for each course in the study. The results of this investigation could reveal the relative contributions of instructional method, specific course cost categories, and their interactive effects to the total training costs.

Type Training Task. Across II and CI courses, training costs were significantly higher for courses that taught a greater percentage of fact or principle tasks than in courses that taught a lower percentage of fact or principle tasks. Training costs were significantly higher in courses that taught a smaller percentage of category, procedure, or rule tasks than in courses that taught a larger percentage of category, procedure, or rule tasks (see table 33).

Method of Instruction by Training Task. Individualized instruction graduates had lower training costs in courses that taught a smaller percentage of fact, rule, or principle tasks than CI graduates in courses that taught a smaller percentage of these tasks. Individualized instruction graduates had higher training costs in courses that taught a smaller percentage of category tasks than CI graduates in courses that taught a smaller percentage of category tasks. II graduates had lower training costs in courses that taught a larger percentage of category tasks than CI graduates in courses that taught a lower percentage of category tasks. Training costs were not significantly related to the percentage of procedure tasks taught by method of instruction (see figure 9 and table 34).

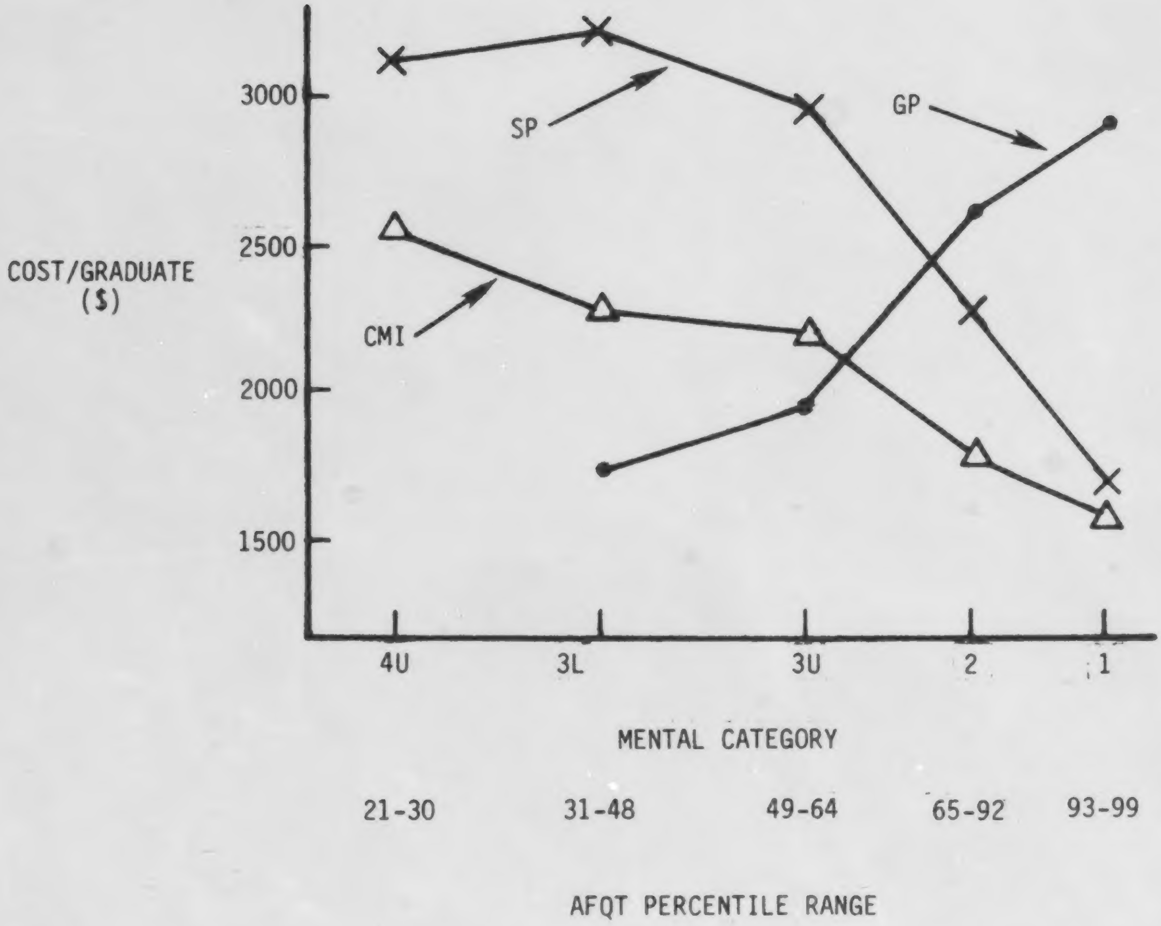


Figure 8. Mean Training Costs By Method of Instruction and Ability Level

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TABLE 32. TRAINING COSTS BY METHOD OF INSTRUCTION AND ABILITY LEVEL

AFQT Percentile	Mental Category	SP			CMI			II (SP + CMI)			CI (GP)		
		Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
93-99	1	$1719.22	750.08	152	$1598.55	345.44	6	$1712.74	738.91	158	$2929.97	1411.37	45
65-92	2	2308.65	969.35	508	1818.22	616.64	167	2187.31	919.41	675	2650.93	1663.19	439
49-64	3U	2929.55	975.91	390	2205.32	668.05	310	2520.24	968.69	700	1950.22	1395.96	851
31-48	3L	3226.99	1295.01	178	2293.60	717.23	281	2655.57	1081.62	459	1787.31	1012.63	341
21-30	4U	3149.95	1035.02	10	2580.32	866.52	21	2764.07	946.16	31	3594.95	621.52	3
10-20	4L		N/A			N/A			N/A		4704.67	0	1

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TABLE 33. TRAINING COSTS BY PERCENT OF TASKS TRAINED

Task	Percent	Mean	SD	N
Fact	1-15	$2995.44	575.07	896
	16-30	4196.78	495.43	66
Category	1-15	2360.07	665.94	2259
	16-20	1535.53	214.71	957
Procedure	1-50	3086.84	471.40	950
	51-100	2010.59	872.19	2842
Rule	1-50	3093.06	651.84	1793
	51-100	2755.93	478.72	295
Principle	1-50	2761.42	519.50	1124
	51-100	2958.58	495.42	349

TABLE 34. TRAINING COSTS BY TRAINING TASK AND METHOD OF INSTRUCTION

		II (SP + CMI)			CI (GP)		
Task	Percent	Mean	SD	N	Mean	SD	N
Fact	1-15	$2488.37	660.89	454	$3516.28	471.64	442
	16-30	N/A	N/A	N/A	4196.78	495.43	66
Category	1-15	2484.52	487.06	1197	2226.65	615.82	1062
	16-30	1549.10	282.22	348	1937.12	164.11	609
Procedure	1-50	2958.62	439.66	312	3149.54	423.30	638
	51-100	2283.01	717.72	1773	1558.74	44.80	1069
Rule	1-50	2863.95	810.68	982	3370.48	378.65	811
	51-100	2755.93	370.72	295	N/A	N/A	N/A
Principle	1-50	2119.20	656.14	602	3681.63	502.08	462
	51-100	N/A	N/A	N/A	2958.60	495.42	349

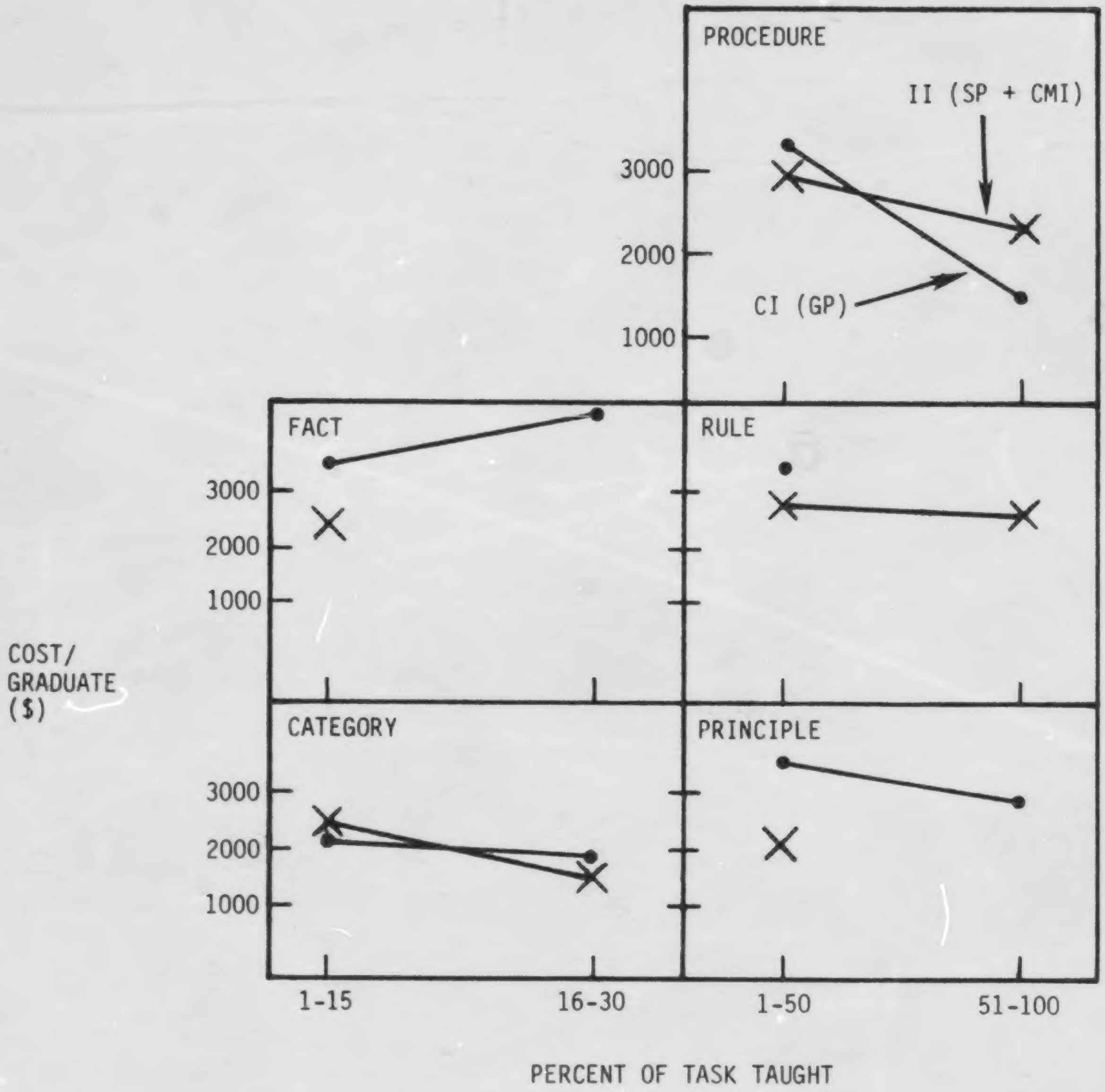

Figure 9. Mean Training Costs By Method of Instruction and Type Training Task

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Time to Complete the Course. In general, individual training costs were greater for graduates who took a longer time to complete their courses than for graduates who completed their courses in less time (R^2 increment = .38). But this was to be expected because training costs were computed using training time as a principal basis.

Nonsignificant Results. The interactions of ability level by training task, and ability level by training task by method of instruction; main effects of sex of graduate and geographic location of school did not significantly predict training costs.

SUMMARY OF FINDINGS

Summaries of the findings of the study are presented next in three tables.

The first table (table 35) lists the predictor variables assessed against four criterion variables: training time, training costs, end-of-course grades, and overall TAS ratings. Significant and nonsignificant results are indicated in the cells. The "direction" of significant results (e.g., whether II has "better" effects than CI) is too complex for simple summarization. Consequently, directionality must be read from the relevant portions of the preceding text.

Table 36 summarizes results of predictor comparisons by five generic task-specific TAS ratings used as criterion variables. Significant and nonsignificant comparisons/results are indicated. Again, however, the direction of effect must be obtained from the text.

The final table (table 37) summarizes the salient findings of the study with respect to the effectiveness and efficiency of training as a function of II versus CI.

TABLE 35. SUMMARY TABLE OF STATISTICAL RESULTS FROM REGRESSION ANALYSES OF FOUR CRITERION VARIABLES BY PREDICTOR AND CRITERION VARIABLES

Predictors	Criterion Variables			
	Training Time	Training Costs	End-of-Course Grades	Overall TAS Ratings
Method of Instruction (MOI):				
II vs CI	X	X	X	X
SP vs CMI	X	X	X	-
Ability (AFQT (A))	X	X	X	-
MOI by A	X	X	X	-
Percentage of Training Task (T):				
Fact	X	X	X	X
Category	X	X	X	X
Procedure	X	X	X	-
Rule	X	X	X	-
Principle	X	X	X	-
T by A	-	-	-	-
T by MOI	X	X	X	-
T by MOI by A	-	-	-	-
Sex of Graduate	-	-	-	-
Geographic School Location	-	-	-	-
Training Time	N/A	X	-	-

- = Nonsignificant results
X = Significant results
N/A = Not applicable to analysis of specific criterion

TABLE 36. SUMMARY TABLE OF STATISTICAL RESULTS FROM REGRESSION ANALYSES OF TASK-SPECIFIC TAS RATINGS BY PREDICTOR AND CRITERION VARIABLES

	Criterion (Task-Specific TAS Ratings)				
Predictors	Fact	Category	Procedure	Rule	Principle
Method of Instruction (MOI):					
II vs CI	-	-	-	-	X
SP vs CMI	-	-	-	-	-
Ability (AFQT (A))	-	-	-	-	-
MOI by A	-	-	-	X	-
Percentage Training Task (T)	-	X	-	-	-
T by A	-	-	-	-	-
T by MOI	-	-	X	X	-
T by MOI by A	-	-	-	-	-

- = Nonsignificant results
X = Significant results

TABLE 37. SUMMARY OF SALIENT FINDINGS OF PERFORMANCE MEASURES OF II GRADUATES COMPARED TO CI GRADUATES

	Outcome of II Graduates (Compared to CI Graduates)			
Measure	Lower	Same	Higher	Comments
Effectiveness				
TAS Ratings			X	Although statistically higher for II graduates, overall TAS ratings support the generalization that II and CI graduates were considered by their fleet supervisors to be adequately trained. Task-specific TAS ratings suggest that CI courses may be more effective in training rule and principle tasks, whereas for II courses, procedure tasks.
End-of-Course Grades			X	Higher ability II graduates received higher grades than lower ability II graduates. Under CI, grades for different ability groups did not differ. Grades for lower ability groups under II and CI did not differ.
Efficiency				
Training Costs			X	It cannot be concluded II is inherently more costly than CI since different courses with different contents and lengths were taught under each method and the same cost factors were not necessarily included in the accounting base for all concerned.
Training Time	X			Because of differences in the courses studied, it cannot be concluded that II necessarily reduces training time over CI. Higher ability II graduates completed their courses in less time than lower ability II graduates.

SECTION IV

DISCUSSION

The results of the study are discussed in this section. Brief discussions of the overall efficiency and effectiveness of II compared to CI are presented first. Discussions of the interrelationships of II with trainee ability levels and with the different types of generic training tasks are then presented.

OVERALL EFFICIENCY

Based on the measures used in this study, no one method of instruction was found clearly to be more efficient than another. Training efficiency--measured in terms of training time and training costs--was independent of fleet measures of training effectiveness. Student completion time and cost to produce a graduate were not reliable indicators of the level of training adequacy reported in the fleet setting for either II or CI graduates.

At the school level, the finding that training costs were higher when producing graduates in less time under II than under CI may not be due primarily to the method of instruction. Rather, it may be due to differences in the factors comprising the cost data bases for specific courses. An analysis of the subcomponents of training costs of II and CI courses would appear to be an appropriate follow-up study into the reasons why training costs are different overall. Similarly, training time differences could be approached in terms of what aspects of courses under II or CI contribute significantly to student time savings. Further investigations of the efficient aspects of conventional instruction, self-paced instruction without computer support, and self-paced with computer support may even lead to an acceptable mixture of methods for use within a given course.

OVERALL EFFECTIVENESS

Fleet supervisor ratings of school training adequacy were used as the external criterion of training effectiveness. On this criterion, the II group was rated significantly higher than the CI group. Although statistically significant, the mean values of ratings for both groups of graduates fell within the same range of values--a range that would be considered to reflect satisfactory school training. Thus, the inference can be made that the two basic methods of instruction are equally effective in preparing graduates for operational jobs. Within the II group, graduates of CMI courses were rated similarly to graduates of SP courses. Accordingly, the two forms of II, SP and CMI, can be considered equally effective from the data of this study.

For the internal criterion of training effectiveness--end-of-course grades--the study results showed significantly higher average end-of-course grades to be associated overall with II. However, this result must be interpreted in terms of the interaction between end-of-course grades and student ability levels. This interaction is discussed in greater detail below.

ABILITY LEVEL OF GRADUATES AND INDIVIDUALIZED INSTRUCTION

The discussions below concern how graduates of different ability levels were affected by II and cover both school and fleet setting criteria.

SCHOOL LEVEL. At the school level, II benefited higher ability graduates more than lower ability graduates. The higher ability II graduates finished their courses sooner and, consequently, were less costly to train than lower ability II graduates. The higher ability II graduates also achieved significantly higher end-of-course grades. This finding is consistent with previous research which has shown positive relationships between student ability and school achievement (see Cronbach & Snow, 1977).

It is interesting to note that those II courses providing end-of-course grades to students used normative (based on a group) measures of performance rather than an all-or-none (go/no-go) mastery criterion which is typically used in an II format. The use of this normative criterion in determining student readiness to graduate apparently did not influence fleet supervisors' perceptions of training adequacy for these graduates. Fleet supervisor ratings were not related to end-of-course grades.

No definitive conclusions concerning training time and training costs could be drawn for the different ability groups trained under CI. For this group, the higher ability graduates tended to be concentrated in courses of greater length. Consequently, over all CI courses, higher training costs were associated with higher ability CI graduates than with lower ability graduates. This reflects an apparent selection bias which may have operated to place higher ability students in longer courses.

No significant relationships were found between end of course grades for the different ability levels trained under CI. End of course grades for the higher ability CI groups were essentially the same as those for the lower ability CI groups.

The failure, in this study, to find a significant relationship between ability levels and grades for CI graduates is interesting since previous research has documented a positive relationship between these two variables (Cronbach & Snow, 1977). Perhaps something is occurring within the CI context that obscures or restricts the potential achievement of higher ability personnel. One possibility is that the grading system used is not sufficiently sensitive to discriminate among students of different abilities. Another is that the CI context contains elements that adversely affect motivation of higher ability students to excel much beyond the minimum school performance criterion. For example, the higher ability CI graduates may have been exposed to a level of training content designed for the majority (i.e., mid to lower ability level) of CI graduates and this material may have posed a limited challenge to the more capable students. Additionally, the higher ability CI graduates' motivation may be affected by their inability to control the amount of time they will spend in the CI course.

To recapitulate, higher ability II graduates mastered relatively more course content than lower ability II graduates and did so in significantly less time. For the CI graduates, however, both end-of-course grades and time to complete training were similar for all ability groups. These findings, taken together, suggest that a CI course converted to an II format would provide a training context in which the school performance of different ability level students is differentiated. For the newly converted course, training costs and training time would be predicted to be lower, and grades higher, for higher ability students. The average course completion time and the amount of improvement, however, can not be specified from the data of the present study. An issue for decision makers would be to weigh the costs and benefits of sending a highly able, trained graduate to the fleet sooner, against the effort involved in converting CI courses to II courses.

There were no definitive findings in the present study to suggest whether lower ability students are more effectively and/or efficiently trained overall in II or CI courses. One point to consider here concerns the frequently made assertion that II provides a context in which lower ability students can achieve the same level of mastery of course content as higher ability students. The lower ability student, however, would presumably require greater time to reach this level. An underlying tenet of II is that students can proceed through training at their own pace. However, those responsible for training may have determined that necessary additional time for course mastery could not be permitted within current operational constraints. Hence, a tradeoff to be made concerns whether the probable increase in grades for lower ability students is worth the additional cost (i.e., greater training time) that would be required to bring all students to an equal level of mastery.

FLEET SETTING. School performance measures, both time to complete training and end-of-course grades, were not related to fleet supervisor ratings of overall training adequacy of II and CI graduates on the job. Also, general ability measures were not related to fleet supervisor ratings. These findings may reflect those of previous research which has reported on the difficulty in demonstrating relationships among graduate ability, school performance measures, and measures reflecting job performance. The failure to find relationships has been particularly noted when supervisor ratings, rather than job knowledge or job sample tests, are used as indices of job performance (e.g., Vineberg, Sticht, Taylor, & Caylor, 1971; Wevrick, 1981). Supervisor ratings provide a greater opportunity for the occurrence of bias than do the other measures. Thus, rater bias is one possible explanation for the failure to find significant relationships among the variables. Another is that the instruments and procedures used for obtaining supervisor ratings are not sufficiently precise or sensitive enough to detect whatever differences may exist.

Evidence was obtained in the present study, however, that student learning of different types of instructional content may be affected by the method of instruction used. Differences were observed on the fleet measures when school training content and items rated by fleet supervisors were classified by generic tasks trained in school. These findings are discussed below.

GENERIC TRAINING TASKS AND INDIVIDUALIZED INSTRUCTION

The discussion below concerns observed relationships between generic training tasks and graduate performance at the school level and in the fleet setting.

SCHOOL LEVEL. School performance of both II and CI graduates was differentially related to the amount of different types of generic tasks taught in school. Across the II and CI courses, graduates of those courses that taught larger amounts of category, procedure, or rule tasks cost less to train, finished their courses sooner, and received higher grades than graduates of courses featuring smaller amounts of these tasks. These same outcomes (i.e., lower cost, less time, and higher grades) were also observed for those II and CI courses that taught smaller amounts of fact or principle tasks compared to courses that taught larger amounts of these tasks. Fleet jobs for which students were required to learn relatively more fact or principle tasks in school than category, procedure, or rule tasks required longer training times. In addition, students achieved less (i.e., got lower course grades) in those courses. Conversely, courses in which training featured greater amounts of category, procedure or rule tasks tended to be shorter and student achievement was higher.

The overall (i.e., across all courses examined) relationships found for generic training tasks were not differentiated by method of instruction or by trainee ability level. Directional changes in school performance measures as a joint function of generic task type and instructional method were inconsistent. In addition, no evidence was obtained in the present study to suggest that school performance of different ability level graduates was affected in any systematic manner by different amounts of generic training tasks taught in the schools sampled.

FLEET SETTING. For the fleet setting, significant differences were observed in overall training adequacy ratings for fact or category tasks. Graduates taught smaller amounts of fact or category tasks in II and CI courses received higher fleet supervisor ratings for overall training adequacy than graduates taught larger amounts of these tasks. These findings are similar to those found for fact tasks at the school level. However, they are opposite in diretion to the relationship observed for category tasks at the school level. These findings suggest that smaller amounts of fact tasks are easier to train and apply on the job than larger amounts of fact tasks. The difference between school and fleet performance findings for category tasks indicates a lack of consistency about which no further interpretation was made.

When the TAS items rated by fleet supervisors were classified by generic tasks trained in both II and CI courses, II was found to be more effective than CI in courses that taught primarily procedure tasks. Conventional instruction was more effective than II in courses that taught primarily rule or principle tasks. These results suggest that training tasks concerned primarily with generalized or cause-effect relationships (rules or principles) may be more adequately presented or learned under a CI format than under an II format. Training tasks concerned mainly with situation-specific, sequential steps (procedures), on the other hand, appear to be more adequately trained under an II format than under a CI format. This suggestion implies that any one course could have both an II format and a CI format to present effectively different kinds of training content to students.

In summary, the results concerned with the interactive effects of ability level and type training tasks with methods of instruction suggest that no one method of instruction is more or less effective/efficient overall. Indeed, some combination of instructional formats within a given course may promote training effectiveness/efficiency to a greater extent than a single format. This combination of formats could be based on different ability levels of incoming students and/or different kinds of generic tasks taught in the school.

Table 38 presents a hypothetical version of how II and CI formats may be assigned to teach different amounts of generic tasks in a course considering the ability level of students. The assignment of II and CI formats is based on the findings in the present study, past research reviewed, and speculation. The purpose of presenting this table is to suggest one approach that instructional designers may use to address the issue of different formats within one course.

TABLE 38. INSTRUCTIONAL FORMATS HYPOTHESIZED FOR DIFFERENT ABILITY LEVELS OF STUDENTS AND GENERIC TRAINING TASKS

	Training Task and Amount Taught*									
	Fact		Category		Procedure		Rule		Principle	
	H	L	H	L	H	L	H	L	H	L
High Ability (mental categories 1 - 3U)	I**	I	I	I	I	I	C***	I	C	C
Low Ability (mental categories 3L - 4L)	C	C	I	I	I	C	C	C	C	C

*H = Relatively high amount; L = Relatively low amount
**I = Individualized format
***C = Conventional format

Note: High and low percentages for tasks taught are:
Fact and category: H: 16-30%, L: 1-15%
Procedure, rule, and principle: H: 51-100%; L: 1-50%

In table 38, under fact, it was assumed that higher ability students could impose their own structure on learning facts, but that lower ability students would require instructor support in learning large numbers of facts. For both higher and lower ability students, an II format was chosen under category tasks because it was assumed that sufficent structure was inherent in the presentation of these tasks in a self-paced mode for all students to learn. An II format was chosen for higher and lower ability students under high amounts of procedure tasks taught, and was based on the task-specific TAS findings in the present study. A conventional format was assigned to lower ability students under low amounts of procedure task, based on the task-specific TAS findings. Higher ability students were assigned an II format for low amounts of procedure tasks based on the assumption that sufficient task structure was inherent in the presentation of this amount of procedure tasks in a self-paced mode. A conventional format was assigned to all students under high amounts of rule tasks based on the task-specific TAS findings. Low amounts of rule tasks were assigned an II format for higher ability students based on task-specific TAS findings. A CI format was assigned for lower ability students based on the assumption that lower ability students would require instructor support in learning the generalization aspect of rule tasks. Conventional formats were assigned to higher and lower amounts of principle tasks trained to all students based on the task-specific TAS findings.

The differences between II and CI formats need not be sharply divided in one course for presenting different tasks. A conventional format could still use an individualized environment (e.g., computer terminal, SP carrel), but could provide instruction in small groups via peers or instructors. Recent evidence (Hopmeier, 1981) has suggested that screening incoming students for personality types can facilitate performance in a computer assisted instruction (CAI) environment. Modifying an II context to incorporate CI format changes reduced student attrition and decreased training time for Navy enlisted personnel. These changes resulted from classifying an individual as introverted (does well in a typical II format) or extroverted (requires the "people" aspect of a CI format). In addition, as noted in Vineberg et al. (1971), a significant number of lower mental category military personnel depended more on the auditory mode rather than the visual mode (i.e., printed material) to obtain job-related information than higher mental category personnel. An issue raised by these findings, then, is whether lower ability students may be more extroverted when learning, and/or whether higher ability students tend to be more introverted in their preference.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

This section contains conclusions about the relative effectiveness/efficiency of II for different kinds of training tasks and ability levels of trainees. Recommendations for II in Navy technical training are also presented.

CONCLUSIONS

Results presented in this report support the following conclusions for the courses studied:

1. Individualized instruction (whether it is self-paced or computer managed) is just as effective as conventional instruction in preparing graduates for operational jobs.

2. Individualized instruction benefits higher ability students during training more than lower ability students.

3. Conventional instruction does not benefit one ability group more than another during training.

4. Fleet performance ratings do not reflect school performance differences or different ability levels of graduates.

5. When course content is classified into generic training tasks, fact or principle tasks are more difficult and time consuming for students in both II and CI courses than category, procedure, or rule tasks. Student end-of-course grades are also lower in courses teaching relatively larger amounts of fact or principle tasks.

6. When the TAS items rated by fleet supervisors were classified by generic tasks trained in both II and CI courses, II was found to be more effective than CI when courses teach primarily procedure tasks. Conventional instruction was more effective than II when courses teach primarily rule or principle tasks.

7. No one method of instruction is more or less effective/efficient in training different types of training tasks to students of different ability levels. Indeed, some combination of instructional formats within a given course may facilitate training effectiveness/efficiency to a greater extent than a single format.

8. Definitive conclusions concerning the efficiency (training costs and training time) of II for Navy training could not be reached from the data of this study.

9. Geographic location of the school and sex of graduate do not significantly influence overall school or fleet performance.

RECOMMENDATIONS

Since this report is based on data analyzed across schools, no specific recommendations are offered to improve individualized instruction in a specific school. The following recommendations pertain to schools grouped by instructional method employed, general ability rankings of students, or generic tasks taught.

Based on these perspectives, the following recommendations are offered:

1. Careful consideration should be given to any attempt to individualize indiscriminately in all schools in the Navy. Rather, the feasibility of employing different instructional formats (instructor involvement, self-pacing, adaptive sequencing, computer support) with differently weighted contributions in a given course should be investigated. A pilot implementation and an ongoing evaluation of a chosen alternative could then be initiated. The goal of such an investigation would be to select cost-effective training systems for different kinds of Navy schools.

2. An economic analysis of subcomponent categories of training costs between schools could reveal resource sources contributing different amounts of money to different aspects of training. Life cycle costs, as one indicator of long-term training efficiency, could be used in conjunction with training effectiveness measures to decide among training efficiency/effectiveness of alternative systems.

3. Attrition of first-term enlisted personnel is an issue of current interest. Completion of first tour of duty could be used as a measure of attrition and could be collected on the graduates in the sample selected for this study. Analysis of attrition data would provide information on the relative influence of the technical schools, general ability level of the graduate, method of instruction, and/or training tasks on explaining potential differences in attrition rates among groups of graduates in the sample investigated. Training effectiveness/efficiency measures at the school level and in the fleet setting could also be treated as potential indicators of attrition.

4. More objective measures of training effectiveness need to be identified and collected for definitive evaluations of alternative training systems. Supervisor ratings are subjective measures which may or may not adequately discriminate individual capabilities to perform on a job for which training was given. Consideration should be given to development and use of more objective measures such as job knowledge and job sample tests for determining training effectiveness. The relationships between supervisor ratings and these types of tests should also be established.

SECTION VI

POSTNOTE

As a result of the study, needs were generated for additional information about II. Consequently, follow-on efforts were initiated. One effort is concerned with SP training time estimates. Another is examining practices used in conducting SP instruction. These efforts were initiated in part by the findings of Freda, Ford, & Hall (1981) that indicated three different data bases for student completion times in individualized courses and instructor preference for conventional instruction over individualized instruction.

SP TRAINING TIME ESTIMATES

While the research literature indicates that II can be more efficient than CI, it is difficult to demonstrate this empirically within the context of a "business as usual" military training environment. One problem is that there are different sources of information concerning student completion times in Navy self-paced courses. Currently, the TAEG is examining several sources of information to determine which source provides the most reliable and accurate baseline estimate of time-to-complete training under SP instruction. This information is indispensable to determining the training efficiency of SP instruction.

PRACTICE OF SP INSTRUCTION

In conducting the present study, the realization arose that, in practice, SP instruction is not a unitary concept. The term apparently has different meanings to different individuals. It was observed during visits to II schools that there are variations in the ways in which SP instruction occurs. These variations may affect what II can achieve. Thus, TAEG initiated an effort to identify the variations in SP instruction and to assess both positive and negative factors associated with the different self-pacing strategies as they affect training efficiency or effectiveness. The thrust here is not to demonstrate that SP instruction is an efficient training method (since this seems to have been amply demonstrated by previous research) but rather how best to achieve the efficiencies. Thus, this study, just underway, will develop recommendations for optimizing the conduct of SP instruction.

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APPENDIX A

SUMMARY OF FINDINGS ON CAI AND CMI COMPARED TO CONVENTIONAL INSTRUCTION

This appendix presents the Orlansky and String (1979) summary of studies on the use of II in military settings.

TABLE A-1 . SUMMARY OF FINDINGS ON CAI AND CMI COMPARED TO CONVENTIONAL INSTRUCTION

Measure			Finding (Compared to Conventional Instruction)		Comments
			CAI	CMI	
Student Achievement			Same or more	Same	Performance measured only at school. Relation between performance at school and on the job not demonstrated. Observed differences not of practical importance.
Course Completion Time	A	No. of Comparisons	40	8	CMI: Most time savings maintained or increased with extended use.
		Time saved (Median)	29%	44%	
		Range	31-39%	12-68%	
	B	No. of Comparisons	5	7	Computer support saves little time beyond that of individualized instruction (i.e., self-paced).
		Time saved: Individualized instruction	64%	51%	
		CAI	69%	CMI 51%	
Student Attrition			About the same	Slight increase may occur	CAI: very limited data CMI: possible decline in student quality
Student Attitudes			Favorable	Favorable	
Instructor Attitudes			Unfavorable	Unfavorable	
Cost			Less due to student time savings	Less due to student time savings	Data limited and incomplete
Cost-effectiveness					Not known because cost data are limited and incomplete

SOURCE: Orlansky and String (1979)

A. Conventional courses converted directly to CAI or CMI.
B. Conventional courses converted to self-paced first and then to CAI or CMI.

APPENDIX B

ASVAB INFORMATION

This appendix describes the subtests comprising the Armed Services Vocational Aptitude Battery (ASVAB). It also provides the routines for converting ASVAB scores to Armed Forces Qualification Test (AFQT) percentiles. The AFQT percentiles were used as measures of general ability for the present TAEG study. The information presented in this appendix pertains to ASVAB usage prior to October 1980. The TAEG study sample of graduates was administered the pre-October 1980 ASVAB version. After October 1980, several changes were made to the item content and test score interpretation of the ASVAB.

TABLE B-1. ASVAB SUBTESTS

Subtest	Abbreviation	Description
General Information	GI	A 15-item general knowledge test, primarily on sports, outdoor activities, automobile mechanics, and history. Testing time is 7 minutes.
Numerical Operations	NO	A 50-item speeded mathematical test, requiring elementary addition, subtraction, multiplication, and division--3 minutes.
Attention to Detail	AD	A 30-item speeded test in which the examinee counts the number of Cs embedded in lines of Os--5 minutes.
Word Knowledge	WK	A 30-item vocabulary test--10 minutes.
Arithmetic Reasoning	AR	A 20-item arithmetic test requiring examinees to solve word problems--20 minutes.
Space Perception	SP	A 20-item pictorial test. Requires examinee to select the three-dimensional figure that could be made from a flat pattern--12 minutes.
Mathematics Knowledge	MK	A 20-item test requiring knowledge of algebra, geometry, fractions, decimals, and exponents--20 minutes.
Electronics Information	EI	A 30-item test requiring knowledge of electrical and electronic components, principles, and symbols--15 minutes
Mechanical Comprehension	MC	A 20-item test about drawings illustrating mechanical principles--15 minutes.
General Science	GS	A 20-item test measuring knowledge in the physical (N = 10) and biological (N = 10) sciences--8 minutes.
Shop Information	SI	A 20-item test on examinee's knowledge about the use of shop tools and practices--8 minutes.
Automotive Information	AI	A 20-item test on automobile parts, operations, or malfunctions--10 minutes.

Notes:

1. Scores reported as Navy Standard Scores (NSS) having a mean of 50 and a standard deviation of 10 for an unrestricted recruit population.
2. AFQT is computed by adding scores for WK, AR and SP. The total is then converted to an AFQT percentile score.

TABLE B-2. PRE-OCTOBER 1980 AFQT CONVERSION: ASVAB FORMS 6 AND 7

The AFQT is computed by adding three raw component scores: WK+AR+SP. The resulting total raw score is then converted to an AFQT percentile score using the following conversion table.

Total Raw Score	AFQT Percentile Score
70	99
69	98
68	97
67	96
66	95
65	94
64	93
63	91
62	89
61	86
60	83
59	80
58	77
57	75
56	73
55	71
54	69
53	67
52	65
51	64
50	62
49	60
48	58
47	56
46	55
45	54
44	52
43	50
42	49
41	48
40	47
39	46
38	45
37	43
36	41
35	39
34	37
33	35
32	33
31	31
30	28
29	25
28	21 (Minimum required for enlistment)
27	19
26	16
25	13
24	11
23	10
22	8
21	7
20	6
18-19	5
16-17	4
14-15	3
12-13	2
0-11	1

ASVAB AFQT Scores	Mental Category
93 to 99	1
65 to 92	2
49 to 64	Upper 3 (3U)
31 to 48	Lower 3 (3L)
21 to 30	Upper 4 (4U)
10 to 20	Lower 4 (4L)

APPENDIX C

SME TRAINING PACKAGE

This appendix is a copy of the package used for training school subject matter experts to classify course learning objectives into the Instructional Quality Inventory (IQI) system. The material is presented in 4 parts as follows:

Part I. Classification Procedures for SMEs Based on a Modified Version of the IQI System

Part II. Question Guide

Part III. Practice Items

Part IV. Classification Guide

Material contained in the package was adapted from Ellis, Wulfeck and Fredericks (1979).

PART I. CLASSIFICATION PROCEDURES FOR SMEs BASED ON A MODIFIED VERSION OF THE IQI SYSTEM

THE INSTRUCTIONAL QUALITY INVENTORY (IQI) SYSTEM

The IQI classification scheme is shown below. Classification of the TAS items is determined according to:

1. What the student must do; that is, the TASK to be performed.

2. The type of information the student must learn; that is, instructional CONTENT.

INSTRUCTIONAL CONTENT

TASK LEVEL	FACT	CATEGORY	PROCEDURE	RULE	PRINCIPLE
REMEMBER	Recall or recognize names, parts, dates, places, vocabulary definitions, etc.	Remember the characteristics of each category and the guidelines for classification.	Remember the steps of the procedure.	Remember the formula or the steps of the rule.	Remember the cause and effect relationships or the statement of the principle.
USE UNAIDED		Classify or categorize objects, events, ideas, according to their characteristics, with no memory aid.	Apply the steps of the procedure in a single situation or on a single piece of equipment, with no memory aid.	Apply the formula or rule to a variety of problems or situations, with no memory aid.	Use the principle to interpret or predict why or how things happened or will happen, with no memory aid.
USE AIDED		Given category characteristics amd guidelines, categorize objects, events, ideas, according to characteristics.	Given steps of the procedure, apply the procedure in a single situation, or on a single piece of equipment.	Given the formula or rule steps, apply the formula or rule to a variety of problems or situations.	Given a statement of the principle, interpret or predict why or how things happened or will happen.

What is being proposed is to classify each TAS item into one of the cells in the above matrix. Inspect the matrix briefly. Note the five types of instructional content across the top, and the three types of task levels down the side. Each cell contains a general description of the performance task. In the following section the detailed procedures for using the IQI are discussed.

CLASSIFICATION PROCEDURE

In order to classify each TAS item, you will have to answer only 4 questions. There are two steps in the classification procedure. The first step determines what the student must do to perform the task (task level). The second step determines the type of information learned to perform the task (content type). Each step is carried out by answering two questions.

Determining the Task Level:

Question 1

Does the TAS item require the student to

Remember or Use

information?

The remember-use distinction can usually be made by looking at the action verb in the item. Typical action verbs are listed below. The ones on the left usually indicate remember tasks, while the ones on the right usually indicate use-level tasks.

REMEMBER

name
state (from memory)
list (from memory)
recall
remember
relate
write (from memory)
recognize
explain (from memory)
describe (from memory)

USE

apply
classify
analyze
derive
demonstrate
discriminate
evaluate
solve
prove
sort
explain (on the basis of other knowledge)
maintain
compute
predict
perform
determine

operate
repair
adjust
calibrate
remove
replace
assemble
disassemble
calculate

troubleshoot
load
unload

Question 2

If the student uses information, is this use of information

Aided or Unaided ?

If the task level is USE, the next question is to determine whether an AID is given. This can be done by looking at the conditions which the TAS item is to be performed. Anything that replaces the need for MEMORY counts as an aid. If the student must perform the task with no memory aid, then the task level is Use-Unaided.

AIDS include:

- a list of procedure steps from a tech. manual or MRC card,
- a formula for solving problems,
- a list or table or chart of characteristics,
- a statement of a principle.

Normal tools, materials, etc., are NOT aids.

Determining the Content Type

Question 3

Does the item only require the student to remember/use information in situations or on types of equipment which were specifically covered or previously seen in training?

Yes or No

The most important requirement to consider is whether or not the student will have to deal with situations or types of equipment not previously encountered during training. For example, if all major instances of information required to perform the TAS item were not presented during training, then answer No. (Examples: (a) student has to classify/identify security codes for different messages, (b) student has to calculate a numerical value using a mathematical formula, (c) student has to troubleshoot a piece of equipment for a faulty module.) If all major instances were presented during training, then answer Yes. (Examples: (a) student has to name the four parts of a specific piece of equipment, (b) student has to perform a routine maintenance procedure on a specific piece of equipment.)

Question 4a

If you answered YES to question 3, is the largest percentage
of information learned to perform the TAS item a

FACT or PROCEDURE ?

FACTS. Facts are what you think they are. They are simple associations between objects, events, names, parts, functions, locations, dates, etc. Facts don't have to come in pairs; there may be three or four or more pieces of information that go together. For example, a student might have to remember the name, location, and function of each of the parts in some piece of equipment. The task is always for the student to recall them or, given one part of the fact, to recall the other parts. Facts by definition must be presented during training.

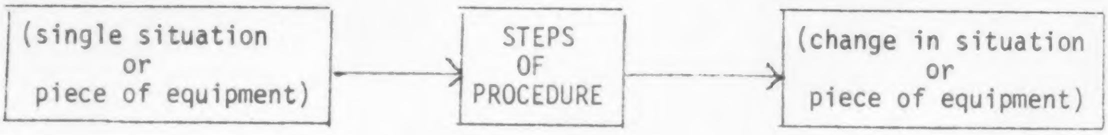
Some key phrases are:

The student will	give the symbol for each ....
	match each ... with its ....
	list the names of each ....
	recall the dates of ....
	recall the location and function of each ....
	given the ... associated with each ....

PROCEDURES. A procedure is a sequence of steps, performed in order, on a single piece of equipment or in a single situation. At the REMEMBER level, the student must remember the steps in order. At the USE level, the student is given a piece of equipment or a situation, and must perform the steps. The job requirements for procedures involve single pieces of equipment or single situations, and the student does not have to "generalize" to new equipments or situaitons. In other words, everything the student needs to know is presented during training.

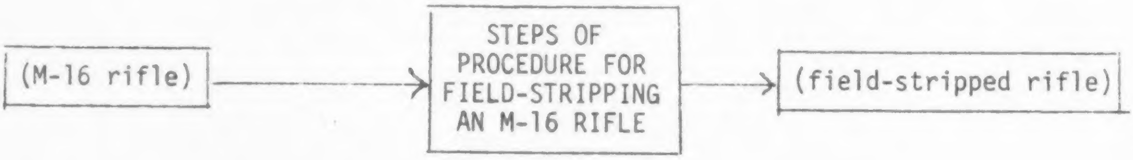
Some key phrases are:

The student will perform the	steps process procedure sequence	for	operating performing maintaining lighting off etc.


(single situation or piece of equipment)
STEPS OF PROCEDURE
(change in situation or piece of equipment)

Example:

"The student will field-strip an M-16 rifle."


(M-16 rifle)
STEPS OF PROCEDURE FOR FIELD-STRIPPING AN M-16 RIFLE
(field-stripped rifle)

Question 4b

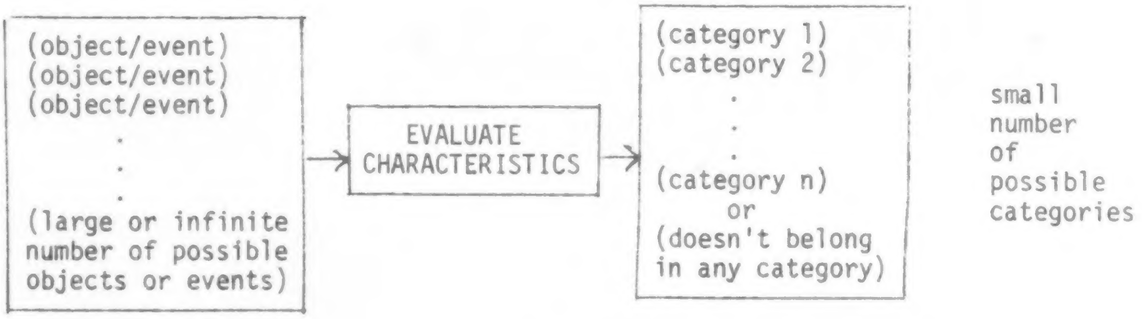
If you answered NO to question 3, is the largest percentage of information learned to perform the TAS item a

CATEGORY or RULE or PROCEDURE ?

CATEGORIES. The CATEGORY content type is used when the job requires that a large number of possible objects, events, etc., be classified into, or identified as a member of, one of a small number of particular categories. Instead of having to remember each object and its classification, the student is given characteristics for each category, which allow him to classify objects, etc., he has not seen before.

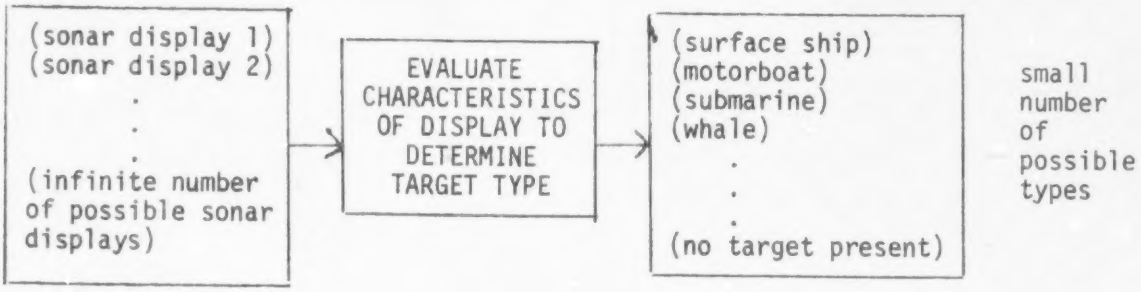
Some key phrases are:

The student will demonstrate the	characteristics features definition attributes	of each	type of ... kind of ... category of classification situation


(object/event)
(object/event)
(object/event)
(large or infinite number of possible objects or events)
EVALUATE CHARACTERISTICS
(category 1)
(category 2)
(category n)
or
(doesn't belong in any category)
small number of possible categories

Example:

"Given a series of sonar scope displays, the student will classify them according to type of target."

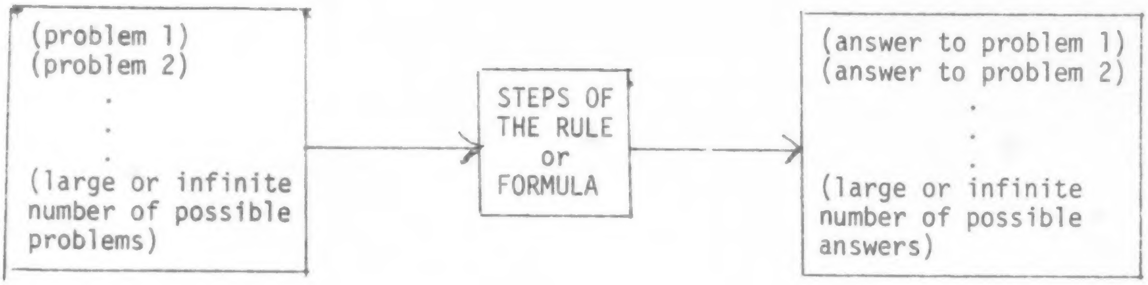

(sonar display 1)
(sonar display 2)
.
.
.
(infinite number of possible sonar displays)
EVALUATE CHARACTERISTICS OF DISPLAY TO DETERMINE TARGET TYPE
(surface ship)
(motorboat)
(submarine)
(whale)
.
.
.
(no target present)
small number of possible types

RULES. A rule, like a procedure, is a sequence of steps and decisions. However, rules can be applied in a variety of situations or on a variety of equipments, whereas a procedure is applied only in a specific situation or on a specific piece of equipment. Instead of having to remember each problem or go through the steps on each object, the student is taught a RULE which allows him to deal with problems, objects, and events he has not seen before.

Formulas and mathematical calculations always involve the use of rules, unless the student has a calculator or computer that does it for him.

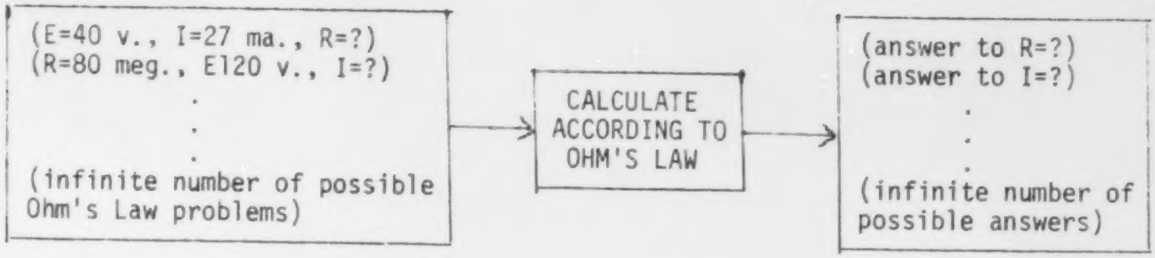
Some key phrases are:

The student will demonstrate the	formula		solving
	rule		deriving
	law	for	proving
	process		calculating
	steps		determining
			etc.


(problem 1)
(problem 2)
.
.
.
(large or infinite number of possible problems)
STEPS OF THE RULE or FORMULA
(answer to problem 1)
(answer to problem 2)
.
.
.
(large or infinite number of possible answers)

Example:

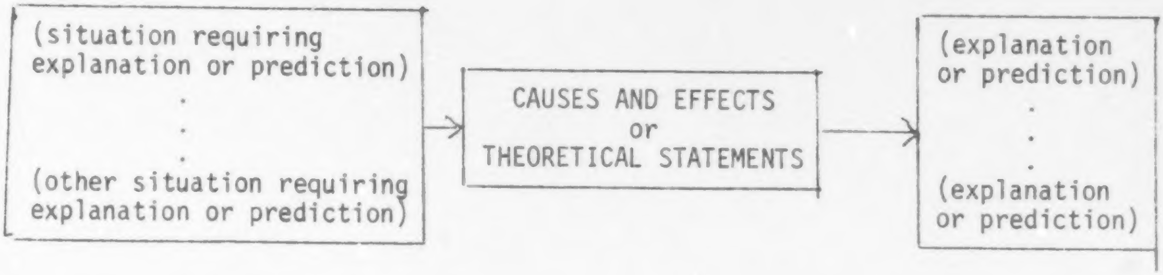
"Given any two values of current, voltage, or resistance in a circuit, the student will use Ohm's Law to solve for the third value."


(E=40 v., I=27 ma., R=?)
(R=80 meg., E120 v., I=?)
(infinite number of possible Ohm's Law problems)
CALCULATE ACCORDING TO OHM'S LAW
(answer to R=?)
(answer to I=?)
(infinite number of possible answers)

PRINCIPLES. Principles involve explanations of why/how things work, or do not work the way they do work, or predictions about "what would happen if ...." Principles are based on cause-effect relationships, theoretical statements, statistical associations, or physical or scientific "laws." Instead of having to remember each possible situation or event and its effects, the student is given a PRINCIPLE which summarizes the "how" or "why" of general situations or which allows the student to predict what is likely to occur in a variety of situations.

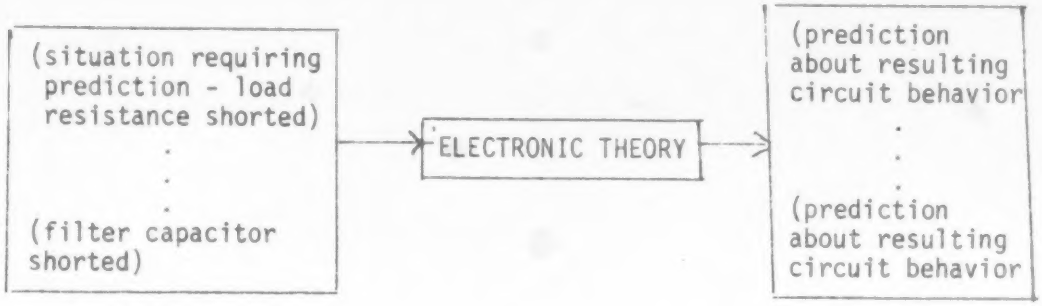
Some key phrases are:

The student will demonstrate	the principle of
	the explanation of
	how ...
	why ...
	the reasons for


(situation requiring explanation or prediction)
(other situation requiring explanation or prediction)
CAUSES AND EFFECTS
or
THEORETICAL STATEMENTS
(explanation or prediction)
(explanation or prediction)

Example:

> Based on his knowledge of electronic theory, the student will predict the effect in the circuit shown below if the load resistance, or the filter capacitor, were shorted.


(situation requiring prediction - load resistance shorted)
(filter capacitor shorted)
ELECTRONIC THEORY
(prediction about resulting circuit behavior
(prediction about resulting circuit behavior

To summarize, there are five content types. Two content types involve performing jobs in situations or on equipment specifically encountered during training. Three content types involve dealing with equipment or situations not specifically presented during training. This explanation is presented in the following table:

Content Type	All Major Instances Covered in Training?
FACT	Yes
CATEGORY	No
PROCEDURE	Yes
RULE	No
PRINCIPLE	No

Sometimes classification can be confusing, especially between FACTS and CATEGORIES, and between PROCEDURES and RULES. The way to resolve problems is to "REMEMBER THE JOB"; that is, to consider carefully what the student must be able to do after instruction.

Again, the most important thing to consider is whether the student will have to deal with objects or situations that he has not seen during training. For example, if the student were required to sort or classify things according to their characteristics, and if the student on the job were going to be dealing with things not seen during training, then the content would be a CATEGORY. However, suppose instead that there were only seven objects the student would ever see. Then, it would be more efficient to teach each object and its category name as a FACT (seven facts total).

Similarly, RULES are taught so that the student can apply his knowledge to situations he did not encounter in training. However, suppose the situations are so similar that "if you've seen one, you've seen them all." This would be more efficiently taught as a PROCEDURE.

Example: FACT vs. CATEGORY

> "Given a variety of metal fasteners, the student will sort them according to type (bolts, screws, studs, or rivets)."
>
> This could be taught as a CATEGORY: the student could be taught the characteristics of bolts (fine threads, blunt end, etc.), the characteristics of screws (coarse threads, pointed end, etc.), the characteristics of studs (no head, fine threads, etc.), and the characteristics of rivets (no threads, etc.). However, one bolt is pretty much the same as any other bolt, and the same for screws, studs, and rivets, except that they come in different sizes. Therefore, it might be more efficient to teach these as four FACTS: bolt - appearance, screw - appearance, etc. The confusion here can be solved if the job requirements are determined. If there are lots of different metal fasteners, and the student will see new bolts, etc., on the job, then the content type is CATEGORY. If there are only a few, and they're all nearly alike, then the content type is FACT.

Example: PROCEDURE vs. RULE

"Given a word in print, correctly spelled, the student will look up the word in a dictionary, and state its definition orally."

This might appear to be a RULE: There are a large number of possible words (inputs), and a large number of possible definitions (outputs). However, since the spelling is given, its easy to look up the word: Find the first letter of the word, find that chapter in the dictionary, find the second letter, find that section of the chapter, etc. This is most efficiently taught as a PROCEDURE.

However, suppose the word was given orally and not spelled. This would then be a fairly complicated RULE, involving listening skills, phonemic translations, etc.

PART II. QUESTION GUIDE

The following sequence of questions should be used to assure consistent judgments in classifying each TAS item:

1. Does the TAS item require the student to remember or use information?

2. If USE information, is performance AIDED or UNAIDED?

3. Is the situation/equipment in the item specifically covered during training?

4a. If covered, is the instructional content in the item primarily a FACT or PROCEDURE?

4b. If not covered, is the instructional content in the item primarily a CATEGORY, RULE, or PRINCIPLE?

PART III. PRACTICE ITEMS

Use the preceding question guide to classify the following sample skill/knowledge items. The items are classified according to the scheme presented earlier. Compare your classification with the one given for each item.

Some of the items will be difficult to classify. There are three reasons for this. First, many of them are not "good" ones; they are written in such a way that it may not be clear what behavior is required or what content is to be taught. (They are, however, fairly typical.) Second, all of them are taken out of context and may deal with unfamiliar topics. Therefore, they are difficult to classify, because information about the job is not provided. Third, some examples were chosen deliberately to be hard to classify, so that classification problems could be illustrated.

For the reasons given above, the reader should not expect to be able to classify perfectly these objectives and test items (or any others) immediately. Since the most important step in classification is REMEMBER THE JOB, the reader should learn to ask the "right" questions of job experts, so that bad items can be revised, and so that unfamiliar topic areas can be classified reliably. The examples are intended to illustrate this "question asking" process.

ITEM

1. State the rule for finding total inductance in a series circuit.

Task Level? REMEMBER

Does the student have to remember something, or perform a task? In this case, the student simply has to recall the correct rule for finding total inductance. Therefore, the task level is Remember.

Content Type? RULE

The student must remember a rule for SOLVING for total inductance. "SOLVE" is a keyword for RULE. The formula for total inductance involves a series of mathematical operations applicable in any series circuit having inductors with various possible values. The process, then, is a series of steps which apply across situations.

It is possible to confuse a piece of information taught at the Remember level for Categories, Procedures, Rules, or Principles, with Remember-Fact information. The difference is that Facts cannot be used immediately. In this case, the student could use the rule to solve inductance problems.

2. Given pictures of the collar devices for different ranks of Naval officers, identify the ranks they represent.

Task Level? REMEMBER

The task here is "I give you a picture of a collar device, and you tell me the rank." Because there is a limited number of different collar devices, the student can learn each device and its name. The task is Remember.

Content Type? FACT

The content type is Fact, because the student has to memorize pairs of symbols and names.

Suppose instead that there were a large number of different ranks and collar devices, but that different groups of them had similar characteristics. If the student's task were to look at a collar device and identify which group it belonged to, then this objective would be Use-Unaided Category.

ITEM

3. Given any resistor with four color bands, state the ohmic value indicated by the color bands.

Task Level? USE-UNAIDED

If there were only a limited number of resistors, the student would ever have to deal with, he could memorize each resistor's colors and their values and the task level would be Remember. However, there are many different resistors with many different color patterns. Therefore, the student must be given a scheme for determining ohmic value from the color pattern. When the student applies this scheme to any particular resistor, he is USING the scheme. If he has no memory aid, then the task level is Use-Unaided.

Content Type? PROCEDURE

In order to make the content type decision, we need to know more about the content than is given in the objective. In particular, we need to know what the scheme for determining ohmic value from the colors is. This is a good time to consult a subject-matter expert. It turns out that the scheme is a fairly simple sequence of steps: the first two color bands indicate the first two significant figures of the ohmic value; the third band is the number of zeros to add. (The fourth band determines tolerance, not value.) If the scheme were more complicated, and involved complex calculations, the content type would be Rule. This one is simple enough to be a Procedure.

This objective should not be confused with simply learning the meanings of the colors. Those are Facts which the student must remember. Those facts support this Use-level objective.

4. State steps involved in message reception and duplicate checking, as listed in the current edition of NTP-4.

Task Level? REMEMBER

The student is asked to recall the steps, not to do anything with them.

Content Type? PROCEDURE

"Steps" is a keyword for Procedure, and in this case the task described in the test item appears to be procedural. It would be a good idea; however, to check with a subject matter expert to make sure.

5. Describe the principles of operation of a rotary gear pump.

Task Level? REMEMBER or USE-UNAIDED

It is difficult to determine whether this objective is Remember or Use-unaided without further information. If the objective had said "The student will recall the principles ...," then it would clearly be Remember. On the other hand, if the objective had said "The student will use his knowledge of hydraulic theory to explain how a rotary gear pump works," then it would be Use-unaided. It is necessary to determine what the student must do after training, and write the objective appropriately.

Content Type? PRINCIPLE

This objective requires the student to explain how or why the pump works. The content type is Principle.

6. Disassemble and reassemble the globe valve using your MRC job program card. The valve, rags, prussian blue, gasket material, packing, and tools are on the workbench.

Task Level? USE-AIDED

The MRC job program card gives the steps to be followed, so the student does not have to remember them.

Content Type? PROCEDURE

This is a series of steps performed on a single piece of equipment.

7. For each of the call signs listed below identify whether it is a Navy ship call sign, a Navy shore call sign, an indefinite call sign, a voice call sign, a task organization call sign, or not a valid Navy call sign.

Task Level? USE-UNAIDED

The task level of this test item depends on complexity of the task. If there were just a few call signs, then it would be easy to memorize their types, and the task would be Remember. Here, though, it turns out that there are several thousand call signs, and the student must use some classification scheme to identify their type. This test item requires the student to use the scheme with no memory aid.

Content Type? CATEGORY

In this case there is a large number of call signs which can be classified into a small number of categories or types.

8. Given the formula for Ohm's Law, and two values, solve for the third value.

Task Level? USE-AIDED

The student must use Ohm's Law to solve for a value. In this case, he is given the formula as a memory aid. He does not have to remember it. The task level is Use-aided.

Content Type? RULE

"Solve" is a keyword for Rules. When the student is asked to solve something, he must perform a series of mathematical operations which result in unique solutions depending on the values used.

9. Recall the duties of a gun captain.

Task Level? REMEMBER

"Recall" is a keyword for the Remember level. The student does not have to perform the duties, only remember what they are.

Content Type? FACT or PROCEDURE

The content type is Procedure if the student is expected to remember a specific sequence of steps which the gun captain must perform. However, if the student is to recall only the general functions of a gun captain, the objective would be a Fact. Again, it is necessary to consult a subject-matter expert to make this decision.

10. "File 30 drill messages representing Top Secret, Secret, special category, readdressed general messages, and other classified and unclassified messages in the correct files."

Task Level? USE-UNAIDED

The student must perform the task, with no memory aid. The task level is Use-unaided.

Content Type? CATEGORY or PROCEDURE

If the student must inspect each message and determine category membership according to its critical characteristics, then the content type is Category. If, however, the classification of the message is obvious (e.g. the classification is printed on the top line of the message), then this is a procedural task involving filing. Once again, the services of a subject-matter expert are required.

11. Give the names of the components represented by the following schematic symbols...

Task Level? REMEMBER

In order to answer this test item, the student would have had to memorize the names of the schematic symbols; therefore, the task level is Remember.

Content Type? FACT

The key phrase in this test item is "Give the names." Simple associations between objects or symbols and their names are Facts.

12. Given the explanation of the principle of supply of a military force from the text, discuss how this principle applies in Hitler's attack on Russia, the Battle of Midway, the Battle of the Bulge, and Sherman's march through Georgia.

Task Level? USE-AIDED

The student is given an explanation of the principle; therefore the task is Aided. The task is Use because the student must apply the principle to explain specific battles. It is assumed that these battles are not discussed in the text and have not been described in class. If they had been, the task level would be Remember and there would be no reason to give the student an Aid.

Content Type? PRINCIPLE

The student is given a principle and asked to interpret the outcome of specific battles. The key words here are "principle" and "discuss."

13. Recall in writing the lofargram characteristics for the following types of contacts: merchant ship, aircraft carrier, destroyer, whale diesel submarine, nuclear submarine.

Task Level? REMEMBER

The student does not have to do anything with the characteristics except recall them; therefore, the task level in Remember.

Content Type? CATEGORY or FACT

The student is asked to memorize characteristics of several categories of contacts presumably because he/she will later have to look at lofargrams and determine what the contact type is. Therefore, the content type is either Fact or Category depending on whether or not this identification requires generalization. If the lofargrams within each category are pretty much identical, then the content type would be Fact. If not, then the content type is Category. The guidance of a subject-matter expert is required.

14. Solve for inductive reactance in a circuit, given frequency and inductance.

Task Level? USE-UNAIDED

The task level is Use because the student is required to solve problems. It is not aided because he/she is not given the formula.

Content Type? RULE

The word "solve" is a keyword for Rule. Here the student must remember the formula for inductive reactance and then use it to solve problems.

15. Perform the steps required to accept, verify, and log messages to be transmitted via teletype tape."

Task Level? USE-UNAIDED

The student must "perform the steps," so the task level is Use. The student has no memory aid, so the task is Unaided.

Content Type? PROCEDURE

The word "steps" is a keyword for Procedure or Rule. If accepting, verifying, and logging is complicated enough so that doing one or two does not mean that the student could do any new message, then the content type would be Rule. In this case, though, the steps are the same for every message, so the content type is Procedure.

16. State the principles of operation of a jet pump as described in Propulsion Engineering Mod 6, Lesson 2.

Task Level? REMEMBER

The student simply has to recall how a jet pump works, as described in his training manual.

Content Type? PRINCIPLE

The student is asked to remember "how" something works. Explanations of how things work are Principles.

17. Use the principle of electromagnetic induction to describe the operation of an AC generator.

Task Level? USE-UNAIDED or REMEMBER

The task level depends on what the student will be taught during the course; that is, on what the other objectives are. If the student must use his knowledge of electromagnetic induction to describe something not yet taught, then the task is Use-unaided. If the student had been taught the principles of operation of an AC generator on the basis of electromagnetic induction, then all the student would have to do is Remember.

Content Type? PRINCIPLE

The student must explain "how" an AC generator works.

18. Given the guidelines for determining message security classification, determine the security classification (Top Secret, Secret, Confidential, or Unclassified) for outgoing messages.

Task Level? USE-AIDED

The student must perform a task: determine appropriate security classifications for a variety of messages. The task level is Use. To the extent that the given guidelines provide sufficient information to determine classifications for varied messages, the task is Aided.

Content Type? CATEGORY

It is expected that the student could take any message and determine which of the four security classifications it belongs in. On the job, he will be required to apply the guidelines to messages he has not seen before. Presumably the messages will be varied enough so that doing one is not like doing them all. The given guidelines should contain characteristics of messages that help determine the type of classification.

From the examples above, it should be clear that the key to classification is REMEMBER THE JOB. Whenever there is doubt about the classification of an item, a subject-matter expert or technical manual should be consulted, so that information about the job can be obtained.

PART IV. CLASSIFICATION GUIDE

Table C-1 presents alphabetically some use-level action verbs classified by instructional content. The checkmarks represent typical classifications of these verbs by information content. Note that these classifications could change due to: (1) the content of the skill item from which these verbs were taken or (2) relevant expert knowledge provided by a subject matter expert (SME). Thus, use this table only as a guide when classifying TAS items.

TABLE C-1. ACTION VERB MATRIX

USE-LEVEL ACTION VERBS	INSTRUCTIONAL CONTENT				
	FACT	CATEGORY	PROCEDURE	RULE	PRINCIPLE
ADJUST			X		
ANALYZE					X
APPLY			X		
ASSEMBLE			X		
CALCULATE				X	
CALIBRATE			X		
CATEGORIZE		X			
CHOOSE		X			
CLASSIFY		X			
COMPUTE				X	
DERIVE				X	
DETERMINE				X	
DIAGNOSE					X
DISASSEMBLE			X		
DISCRIMINATE		X			
EXPLAIN					X
EVALUATE					X
IDENTIFY		X			
LIST	X				
LOAD			X		
MAINTAIN			X		
MATCH	X				
NAME	X				
OPERATE			X		
PERFORM			X		
PREDICT					X
PREPARE			X		
PROVE				X	
RECOGNIZE		X			
REMOVE			X		

TABLE C-1. ACTION VERB MATRIX (continued)

USE-LEVEL ACTION VERBS	INSTRUCTIONAL CONTENT				
	FACT	CATEGORY	PROCEDURE	RULE	PRINCIPLE
REPAIR			X		
REPLACE			X		
SELECT		X			
SOLVE				X	
SORT		X			
TROUBLESHOOT					X
UNLOAD			X		

APPENDIX D

COST DATA

This appendix describes how training cost data were computed for use in the present study. A strategy for choosing among alternate training systems on cost and effectiveness bases is also described.

Training costs should include both complete investment and operating costs. Investment costs are "front-end" expenditures associated with such items as equipment, classroom buildings, curriculuum development. Operating costs are "ongoing," repetitive expenditures. They include items such as staff costs (e.g., pay, health, food), student costs (pay, health, food, time in school, rate), and travel.

In the Per Capita Course Costing Data Base maintained by the Chief of Naval Education and Training (CNET), many investment costs, such as facilities and curriculum development costs, are not included. The data base emphasizes operating costs which are primarily military pay and allowances (MPN) and operating and maintenance, Navy (O&MN) costs. MPN reflects military staff and student costs: O&MN costs account for civilian pay, some supplies, and travel. An "other" category is also used to classify miscellaneous items. Based on the cost data available for the schools in the present TAEG study, MPN accounted for approximately 74 percent, O&MN for approximately 26 percent, and "other" for less than 1 percent of total training costs.

The incremental costing model (System I)[1] was used with the CNET Per Capita Course Costing Data Base in the present TAEG study to calculate the total training costs to produce one graduate per average course session (based on FY-79 dollars). Costs to produce an individual graduate per specific course were computed by multiplying the average course cost to produce one graduate, by the ratio of a given student's time to complete the course to the average course completion time. This metric provided the variance required to use training costs as a criterion variable (see section III in the report concerning training costs for application of the metric in the analyses). However, since the full measure of resource and development costs[2] are not adequately stated in the data base, the results of training cost analyses should be viewed with caution.

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[1] W. M. Swope, Cynthia Yelvington, and J. M. Corey, Incremental Costing Model for Use with the CNET Per Capita Course Costing Data Base: System I. TAEG Report No. 77, November 1979. Training Analysis and Evlauation Group, Orlando, FL 32813 (AOAD81759).

[2] J. M. Corey, "The full measure of resource costs." Defense Management Journal, Third Quarter, 1980, 18-23.

The selection of appropriate variables and measures is important not only for training costs but also for training effectiveness. Figure D-1 presents a theoretical outcome matrix of possible decisions based on cost and effectiveness factors underlying the alternative systems/programs being compared. Full measures of costs and effectiveness are required to diminish the occurrence of dilemmas in choosing a cost-effective alternative.

		EFFECTIVENESS		
		LOWER	SAME	HIGHER
COST	HIGHER	NO	NO	?
	SAME	NO	EQUAL	YES
	LOWER	?	YES	YES

Figure D-1. Decision Outcome Matrix of Cost and Effectiveness Comparisons

The Decision Outcome Matrix shown considers two factors: cost and effectiveness. Each factor is gradated ordinally. Each matrix cell represents the joint outcome of a specified alternative system/program being compared to another on cost and effectiveness factors. It is assumed that decision outcomes can be obtained from at least an ordinal scale of measurement.

Note that out of the possible 9 outcomes, the two marked by a "?" suggest other areas of possible concern in cost and effectiveness comparisons. More factors may be taken into consideration when a highly effective system is the most costly alternative, or when a less effective system is the least costly. The joint outcome may be expressed as the desirability and/or certainty of selecting a specified alternative system/program. For example, system A costs less than, and is more effective than, system B. Thus, a desirable outcome of YES is indicated in the matrix for selecting A. However, if A costs more, as well as being more effective than B, then a "?" desirability is indicated.

One strategy, to prepare for all possible outcomes, is to use a multi-variable, multi-measurement approach to determine cost and effectiveness. The multi-variable aspect of this approach refers to an expansive effort to select those classes of measures that contribute totally or proportionately to the cost and/or to the effectiveness of the comparison systems/programs. Then, once the variables are selected, various measures can be employed to represent the same or different variables. This multi-measurement aspect increases the probability of observing a correlated pattern among the measures for all the variables used to reflect cost and effectiveness. Further analyses are conducted to determine the significance of obtained correlated patterns. The multi-variable, multi-measurement approach may also lessen the occurrence of "?" outcomes, if such outcomes are predominately influenced by an insufficient number of variables and/or measures selected.

APPENDIX E

COURSES INCLUDED IN THE STUDY

The full names and locations of the schools/courses examined during the study program are presented in this appendix.

TABLE E-1. COURSES INCLUDED IN THE STUDY

School/Course Name	Symbol	Location	Method of Instruction
Hull Maintenance Technician Class "A" School Phase II	HT-II	San Diego, CA	Mixed[1]
Radioman "A" Sea School	RM-SEA	San Diego, CA	GP[2]
Radioman "A" Shore School	RM-SHORE	San Diego, CA	GP[2]
Damage Control Assistant "A2" Course	DCA	Treasure Island, CA	GP[3]
Hull Maintenance Technician Class "A" School Phase I	HT-1	Treasure Island, CA	GP
Damage Control Assistant "A2" Course	DCA	Philadelphia, PA	SP[3]
Hull Maintenance Technician Class "A" School Phase I	HT-1	Philadelphia, PA	GP
Hull Maintenance Technician Class "A" School Phase II	HT-II	Philadelphia, PA	SP
Electrician's Mate "A" School	EM	Great Lakes, IL	GP
Engineman "A" School	EN	Great Lakes, IL	CMI[4]
Fire Control Technician "A" School Phase I	FT	Great Lakes, IL	GP
Gunner's Mate "A" School	GM	Great Lakes, IL	GP
Machinist's Mate 600 psi "A" School	MM-600	Great Lakes, IL	SP[5,6]
Machinist's Mate 1200 psi "A" School	MM-1200	Great Lakes, IL	SP[5,6]

TABLE E-1. COURSES INCLUDED IN THE STUDY (continued)

School/Course Name	Symbol	Location	Method of Instruction
Instrumentman "A" School	IM	Great Lakes, IL	SP
Aviation Support Equipment Technician Electrical "A1" Course	ASE	Millington, TN	GP
Aviation Machinist's Mate "A" School	AD	Millington, TN	CMI[7]
Aviation Electrician's Mate "A" School	AW	Millington, TN	GP
Aviation Technician Training Deviceman "A" School	TD	Millington, TN	SP
Personnelman "A" School	PN	Meridian, MS	SP
Yeoman "A" School	YN	Meridian, MS	SP
Disbursing Clerk "A" School	DK	Meridian, MS	SP
Aviation Storekeeper "A" School	AK	Meridian, MS	SP
Ship's Serviceman "A" School	SH	Meridian, MS	GP

[1] Group-assisted self-paced (GRASP)

[2] CMI data from RM Basics obtained from CNTECHTRA (CDP 6144; 894 records)

[3] Officer course

[4] CMI data from PE Basics obtained from CNTECHTRA (CDP 6261; 359 records)

[5] CMI data from PE Basics obtained from CNTECHTRA (CDP 6262; 552 records)

[6] 1978 student training records obtained from National Archives via CNTECHTRA and PE School.

[7] CMI data obtained from CNTECHTRA.

APPENDIX F

DISCUSSION OF THE PARTIAL HIERARCHICAL REGRESSION MODEL

The partial hierarchical regression model used in data analyses is discussed in this appendix. Terms used in the model are explained and the model is specified in mathematical notation.

DESCRIPTION OF THE PARTIAL HIERARCHICAL REGRESSION MODEL

A partial hierarchical regression model was used to analyze the data of the study. A hierarchial model is one in which the predictors are entered cumulatively into the regression equation according to a specified hierarchy (or order) dictated in advance by the purpose and logic of the study. In the present TAEG study, this hierarchy was directed by the tasking questions; method of instruction was entered first; ability level and training tasks second; and the two-way and three-way interactions formed by the previously entered predictors were entered subsequently. Since the predictors were entered as groups (sets) in each step of the equation, rather than entered individually, the model is called partial hierarchical regression. In partial hierarchical regression, the variables within each group (or set) are analyzed in a forward stepwise manner[3] at each step of the equation, and each group of variables is analyzed hierarchically between sets. The R^2 for all predictor sets can thus be analyzed into increments in the proportion of the criterion variance due to the addition of each new set of predictors to those higher in the hierarchy. These increments in R^2 are squared multiple semipartial correlation coefficients and represent the increments of criterion variance accounted for by a given set of predictors beyond what has already been accounted for by the prior sets. An advantage of the hierarchical model is that once the order of the predictor sets has been specified, a unique partitioning of the total criterion variance accounted for by all predictor sets may be made.

An issue raised by the use of the partial hierarchical regression model concerns the basis for determining the extent of contribution of any group of variables once the entry order is specified in the equation. Since the contribution of the first set of predictors is determined from its initial entry in the equation, subsequent potential changes in the contribution by the first predictor set when other variables are entered later into the equation do not influence the decision made from the initial entry of the first predictor set. For example, if the standardized partial regression coefficient of the first predictor set moves toward zero when later predictor sets are added to the equation, the situation is one of simple redundancy between the first and later predictor sets in accounting for the criterion variance. If, on the other hand, the regression coefficients of the first predictor set changes sign or increases, the relationship between the first and later predictor sets is one of suppression (see Cohen & Cohen (1975) for further discussion of this issue). With respect to the present TAEG study, examination of the standardized partial regression coefficients

[3] Forward stepwise regression selects from a group of predictors the one predictor at each stage that has the largest squared semipartial correlation coefficient, and hence makes the largest contribution to R^2.

of the first predictor set of methods of instruction revealed no significant or relevant changes when the predictor set of ability level and training tasks was entered later in the equation. Thus, entering methods of instruction into the equation first (based on the tasking questions) did not result in redundancy or suppressive effects not explained by main effects or interactions.

EXPLANATION OF REGRESSION TERMS COMMON TO ALL EQUATIONS IN THE MODEL

R^2 refers to the proportion of the criterion variance shared with the optimally weighted predictor variables.

R^2Increment is the cumulative increase in the proportion of criterion variance explained due to the addition of each set of predictors entering at the point in the equation, beyond the criterion variance already accounted for by the previously entered sets of predictors. These increments in R^2 are squared semipartial correlation coefficients. They represent the unique contribution of a predictor to R^2 in the context of the remaining predictors (expressed as a proportion of the total criterion variance, since the effects of the remaining predictors have been removed from the specific predictor but not from the criterion).

B refers to the raw score partial regression coefficient. B is the constant weight by which each value of a predictor is to be multiplied in the equation and reflects the average or expected change in the criterion value for each unit increase in each predictor when the values of the remaining predictors are held constant.

C is the regression constant or Y intercept for each equation, and serves to make appropriate adjustments for differences between the mean predictor values and mean criterion values (e.g., gives the predicted criterion value when predictor values=0; i.e., is the mean of the criterion variable).

$\hat{Y}$ refers to the predicted value of the criterion variable. In the regression model, Y represents predicted values for each of the criterion variables used in the present study.

X refers, in general, to a set of predictor variables.

SPECIFICATION OF THE MODEL

The number preceding each equation refers to the order (step) in which each set of predictors was entered into the regression equation.

1. $\hat{Y} = \sum_{i=1,2} B_i X_i + C$

where X_i is composed of two coded predictors each representing different contrasts between methods of instruction.

2. $\hat{Y} = \sum_{i=1,2} B_i X_i + \sum_{j=1,6} B_j X_j + C$

where X_j is composed of six continuous predictors, one representing AFQT and the remaining, five types of training tasks in percentages of task taught in school.

3. $\hat{Y} = \sum_{i=1,2} B_i X_i + \sum_{j=1,6} B_j X_j + \sum_{k=1,12} B_k X_k + C$

where X_k is composed of 12 two-way interaction terms, 10 of which were formed from two predictors of methods of instruction and five predictors of training tasks, and two from two predictors of methods of instruction and one predictor of ability level.

4. $\hat{Y} = \sum_{i=1,2} B_i X_i + \sum_{j=1,6} B_j X_j + \sum_{k=1,12} B_k X_k + \sum_{l=1,5} B_l X_l + C$

where X_l is composed of five two-way terms that were formed from one predictor of ability level and five predictors of training tasks.

5. $\hat{Y} = \sum_{i=1,2} B_i X_i + \sum_{j=1,6} B_j X_j + \sum_{k=1,12} B_k X_k + \sum_{l=1,5} B_l X_l + \sum_{m=1,10} B_m X_m + C$

where X_m is composed of 10 three-way interaction terms formed from two predictors of methods of instruction, one predictor of ability level, and five predictors of training tasks.

6a. $\hat{Y} = \sum_{i=1,2} B_i X_i + \sum_{j=1,6} B_j X_j + \sum_{k=1,12} B_k X_k + \sum_{l=1,5} B_l X_l + \sum_{m=1,10} B_m X_m + BS + C$

where S is one coded predictor representing sex of graduate.

6b. $\hat{Y} = \sum_{j=1,2} B_i X_i + \sum_{i=1,6} B_j X_j + \sum_{k=1,12} B_k X_k + \sum_{l=1,5} B_l X_l + \sum_{m=1,10} B_m X_m + \sum_{n=1,3} B_n L_n + C$

where L_n is composed of three coded predictors representing school locations.

6c. $\hat{Y} = \sum_{i=1,2} B_i X_i + \sum_{j=1,6} B_j X_j + \sum_{k=1,12} B_k X_k + \sum_{l=1,5} B_l X_l + \sum_{m=1,10} B_m X_m + BG + C$

where G is one continuous predictor representing end-of-course grades. G was used as a predictor only when Y = TAS rating.

6d. $\hat{Y} = \sum_{i=1,2} B_i X_i + \sum_{j=1,6} B_j X_j + \sum_{k=1,12} B_k X_k + \sum_{l=1,5} B_l X_l + \sum_{m=1,10} B_m X_m + BT + C$

where T is one continuous predictor representing training time. T was used as a predictor only when Y = TAS rating or training cost.

Predictor sets and individual predictor variables are delineated below.

X_i = T1, T2 where T1 = II (SP + CMI) vs CI; contrast coded as II (SP = $-\frac{1}{2}$, CMI = $-\frac{1}{2}$) = -1, CI = 1, and T2 = SP vs CMI, coded SP = -1, CMI = 1, CI = 0.

X_j = A, I1, I2, I3, I4, I5 where
A = AFQT Percentile
I1 = Percentage of Fact Task
I2 = Percentage of Category Task
I3 = Percentage of Procedure Task
I4 = Percentage of Rule Task
I5 = Percentage of Principle Task

$X_k = T_1I_1, T_1I_2, T_1I_3, T_1I_4, T_1I_5, T_2I_1, T_2I_2, T_2I_3, T_2I_4, T_2I_5, AT_1, AT_2$

$X_l = AI_1, AI_2, AI_3, AI_4, AI_5$

$X_m = AT_1I_1, AT_1I_2, AT_1I_3, AI_1I_4, AT_1I_5, AT_2I_1, AT_2I_2, AT_2I_3, AT_2I_4, AT_2I_5$

S = Sex of graduate; dummy-variable coded as male = 1, female = 0

L_n = L1, L2, L3; effects coded as
L1 = 1 if San Diego, CA
and -1 if Meridian, MS
L2 = 1 if Great Lakes, IL
and -1 if Meridian, MS
L3 = 1 if Millington, TN
and -1 if Meridian, MS

G = Average end-of-course grades (percent correct)

T = Training time (contact hours)

The increments in R^2 accounted for by the previously mentioned predictor sets can be described by the following equation:

$$R^2_{Y.X_1X_2X_3...k} = R^2_{YX_1} + R^2_{Y(X_2.X_1)} + R^2_{Y(X_3.X_1X_2)} + \cdots + R^2_{Y(k.X_1X_2X_3...k-1)}$$

The increments in R^2 are squared multiple semipartial correlation coefficients. Each R^2 increment is an increase to the proportion of criterion variance accounted for by a given predictor set beyond what has already been accounted for by prior sets (i.e., sets higher up in the hierarchy). Further, the amount of the increment in criterion variance accounted for by that set can not be influenced by criterion variance associated with subsequent sets (i.e., those lower in the hierarchy).

APPENDIX G

MISSING DATA ANALYSIS

This appendix presents the findings (with accompanying statistical tables and breakdown) of the missing data analysis. The purpose of this analysis was to determine if graduates with data present differed from those with data absent. Headings used in this subsection are listed by the criterion variables.

CRITERION: PRESENCE VS. ABSENCE OF TAS RATINGS

Only main effects (and no interactions) were found in the regression analyses presented in table G-1.

TABLE G-1. SIGNIFICANT RESULTS FROM REGRESSION ANALYSES OF ABSENT TAS RATINGS

Step	Variables	B	F	DF	R^2 Increment	Overall F	DF
1	II vs CI (T1)	-.16	234.46	1/4003	.0811	176.54	2/4003
	SP vs CMI (T2)	.13	184.89	1/4003			
2	AFQT (A)	.002	18.25	1/3998	.0375	34.03	4/3998
	Fact (I1)	.02	56.02	1/3998			
	Principle (I4)	-.003	40.88	1/3998			

The following findings are listed by significant predictor variables.

1. Method of Instruction. A larger percentage of TAS ratings was absent from both SP and CMI graduates than from GP graduates. TAS ratings were absent more from CMI graduates than from SP graduates (see table G-2).

TABLE G-2. ABSENT TAS RATINGS BY METHOD OF INSTRUCTION

	Original Sample Size	Absent TAS Ratings	
	N	N	%
SP	1451	560	39
CMI	823	536	65
GP	1732	495	29
TOTAL	4006	1591	40

2. Ability Level. TAS ratings were absent more from data of graduates of extremely lower and upper ends of mental categories than from the middle mental categories (see table G-3).

TABLE G-3. ABSENT TAS RATINGS BY ABILITY LEVEL

		Original Sample Size	Absent TAS Ratings	
AFQT Percentile Range	Mental Category	N	N	%
93-99	1	228	113	50
65-92	2	1211	503	42
49-64	3U	1608	586	36
31-48	3L	828	341	41
21-30	4U	36	22	61
10-20	4L	1	0	0
	Missing AFQT	94	26	28
	Total	4006	1591	40

3. Training Task. More TAS ratings were absent from graduates who attended courses that taught a relatively smaller percentage of fact or rule training tasks than those that taught a larger percentage of these tasks (see table G-4).

TABLE G-4. ABSENT TAS RATINGS BY TRAINING TASK

	Percent Task Taught in Courses									
	0		1-25		26-50		51-75		76-100	
Task	N	%	N	%	N	%	N	%	N	%
Fact	1036	34	555	56	-	-	-	-	-	-
Rule	733	40	670	46	133	31	23	12	32	29

CRITERION: PRESENCE VS. ABSENCE OF TIME TO COMPLETE (STUDENT CONTACT HOURS BASED ON SCHOOL RECORDS)

Only main effects (and no interactions) were found in the regression analysis presented in table G-5.

TABLE G-5. SIGNIFICANT RESULTS FROM REGRESSION ANALYSES OF ABSENT TIME TO COMPLETE THE COURSE (CONTACT HOURS) DATA

Step	Variables	B	F	DF	R^2 Increment	Overall F	DF
1	II vs CI (T1)	-.02	11.66	1/4003	.0239	49.18	2/4003
	SP vs CMI (T2)	-.05	72.16	1/4003			
2	Category (I2)	-.002	8.41	1/3998	.0528	228.64	5/3998
	Procedure (I3)	-.002	111.99	1/3998			
	Rule (I4)	-.004	189.64	1/3998			

The following findings are listed by significant predictor variables.

1. Method of Instruction. A larger percentage of time to complete data was absent from SP and CMI graduates than GP graduates. Time to complete data were absent more from SP graduates than from CMI graduates (see table G-6).

TABLE G-6. ABSENT TIME TO COMPLETE DATA BY METHOD OF INSTRUCTION

	Original Sample Size	Absent Time to Complete	
	N	N	%
SP	1451	168	12
CMI	823	20	2
GP	1732	68	4
Total	4006	256	6

2. Training Task. More time to complete data were absent from graduates who attended courses that taught a relatively smaller percentage of category, procedure, or rule training tasks than those that taught a larger percentage of those tasks (see table G-7).

TABLE G-7. ABSENT TIME TO COMPLETE DATA BY TRAINING TASK

	Percent Task Taught in Courses									
	0		1-25		26-50		51-75		76-100	
Task	N	%	N	%	N	%	N	%	N	%
Category	26	4	219	7	11	14	-	-	-	-
Procedure	-	-	68	9	1	1	141	15	46	2
Rule	128	7	105	7	23	5	-	-	-	-

CRITERION: PRESENCE VS. ABSENCE OF END-OF-COURSE GRADES

Only main effects (and no interactions) were found in the regression analyses presented in table G-8.

TABLE G-8. SIGNIFICANT RESULTS FROM REGRESSION ANALYSES OF ABSENT END-OF-COURSE GRADES

Step	Variables	B	F	DF	R^2 Increment	Overall F	DF
1	II vs CI (T1)	.14	196.28	1/4003	.1197	272.38	2/4003
	SP vs CMI (T2)	-.21	440.00	1/4003			
2	Category (I2)	-.01	270.82	1/3998	.6453	337.13	5/3998
	Procedure (I3)	-.01	1242.45	1/3998			
	Rule (I4)	-.01	692.24	1/3998			

The following findings are listed by significant predictor variables.

1. Method of Instruction. A larger percentage of end-of-course grades was absent from GP graduates than from both SP and CMI graduates. End-of-course grades were absent more from SP than from CMI graduates (see table G-9).

TABLE G-9. ABSENT END-OF-COURSE GRADES BY METHOD OF INSTRUCTION

	Original Sample Size	Absent End-of-Course Grades	
	N	N	%
SP	1451	867	60
CMI	823	131	16
GP	1732	964	56
Total	4006	1962	49

2. Training Task. More end of course grades were absent from graduates who attended courses that taught a relatively larger percentage of procedure or rule tasks, or a smaller percentage of category tasks than courses that taught smaller or larger amounts of these tasks, respectively (see table G-10).

TABLE G-10. ABSENT END-OF-COURSE GRADES BY TRAINING TASK

	Percent Task Taught in Courses									
	0		1-25		26-50		51-75		76-100	
Task	N	%	N	%	N	%	N	%	N	%
Category	97	16	1854	56	11	14	-	-	-	-
Procedure	-	-	253	32	2	1	374	39	1333	65
Rule	1136	62	387	27	254	59	185	100	-	-

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